COMBUSTION

MAY 7 1946

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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BRARY

April, 1946

Welding reinforcing pad on drum head. Rotation of head is under control of operator so as to weld in most convenient position.

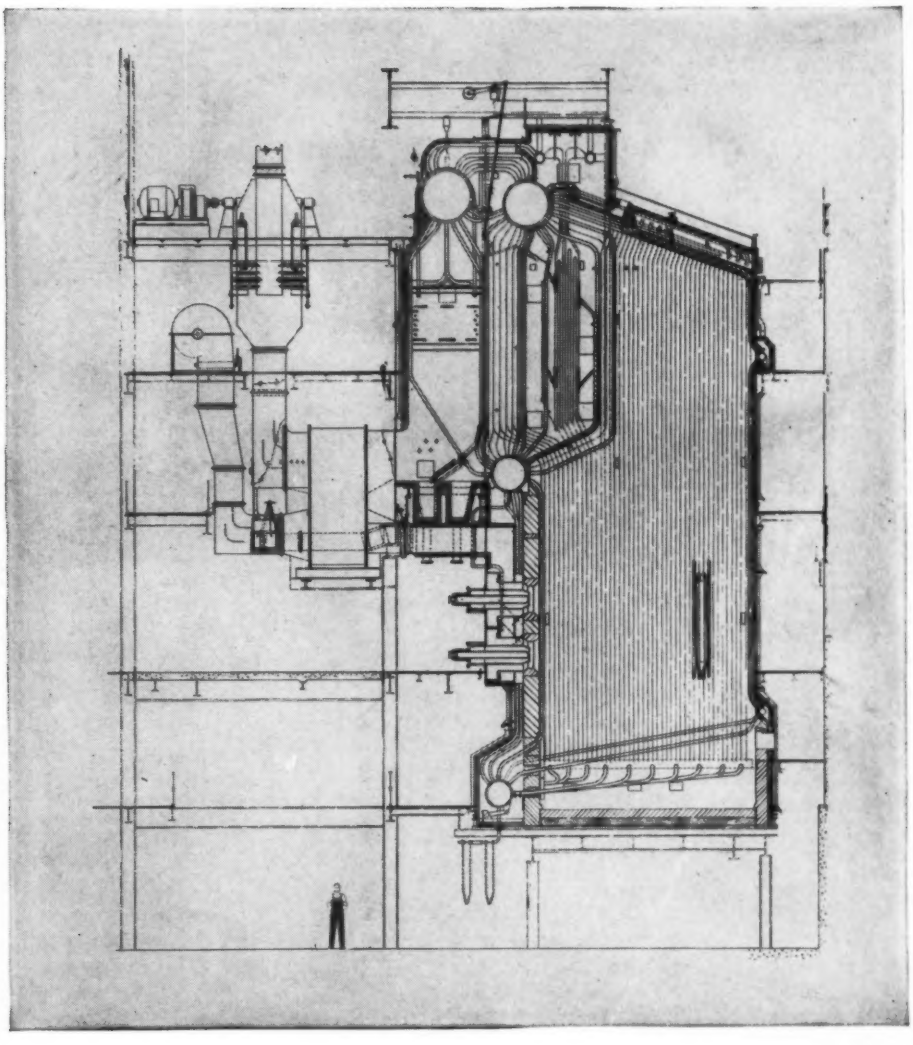
Semi-Outdoor Steam Plants

Evaporators and Their Operation

Midwest Power Conference

Fabrication of Boiler Drums—Part 2, Welding

ABILENE *Repeats*



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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME 17 **NUMBER 10**

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Editorial

Obstacles to Standardization

To those not intimately familiar with power plant design and practice it often appears strange that so little standardization prevails, despite its apparent advantages.

Overall plant requirements such as size, load conditions, space limitations in existing buildings, fuel characteristics, steam and feedwater conditions, as well as economic considerations and customer preference, are factors primarily responsible for the many differences in steam-generating equipment; although admittedly steam conditions could well be narrowed. The present trend toward designing furnaces and firing equipment to burn a wide range in coals will simplify the fuel burning problem.

But the turbine end of the plant, contrary to general impressions, appears also to be subject to wide variations, particularly for industrial power plants, as was brought out by Mr. Newman in his paper before the Midwest Power Conference. For sizes up to 7500 kw he cited 112 different designs by one manufacturer, as brought about by differences in ratings and basic types; and this figure is amplified many times by variations in initial pressure, exhaust and extraction pressures, and extraction flows; not to mention special voltages and frequencies, as are often required for certain processes of manufacture.

The problem, as concerns central stations and industrial power plants, appears to affect boiler and turbine designers differently. Large steam generating units, such as employed in central stations, are usually "tailored" to meet specific conditions, whereas the latest turbines for such stations fall within six standard ratings with generally two throttle pressures and temperatures for each rating, as prescribed by the "Preferred Standards for Turbine-Generators of 10,000 Kw and Above." Of course, there are some departures from these standards.

On the other hand, the industrial plants are more susceptible to a greater degree of standardization in steam-generating units, especially in the smaller sizes; but make far wider demands on the turbine manufacturers, because of the variation in processes involved.

Obviously, the field of power generation cannot remain static. Development must go forward to meet ever-changing economic demands and material progress. Hence there will always be installations that pioneer with new advances, and as these become proven they are adopted as general practice. However, for the average plant, a partial answer to the problem seems to be the development of flexible designs into which more or less standardized parts can be assembled. This is now being done to some extent.

SEMI-OUTDOOR STEAM PLANTS*

By P. E. GOURDON, W. F. FRIEND and LOUIS ELLIOTT

Designing and Consulting Mechanical Engineers, Ebasco Services Incorporated, New York

A review of fifteen semi-outdoor installations, covering a considerable range in capacities, which have been engineered by the authors' company. The economics of this type of construction are discussed and indicate a saving in initial investment of $5 to $10 per kilowatt, compared with the conventional fully housed plant.

A LARGE proportion of steam-electric stations designed and constructed for clients during the past ten or fifteen years have been of semi-outdoor type, or have, with respect to installation of major equipment, included important outdoor features.

Saving accomplished by this design type, as compared with fully housed plants, is difficult to determine precisely. A comparison, in order to be fair, must be based on reasonably complete design for a typical station of each of the two types. To extend the housing so as to provide minimum enclosure for an equipment layout made for a semi-outdoor installation would cost, at present price levels, roughly $6 per kw, for a moderate-size, single-turbine plant. However, it is natural that a fully housed plant should carry with it somewhat greater elaboration than would the minimum compact installation designed for semi-outdoor construction; hence a true evaluation of saving effected by utilizing the outdoor type may be nearer $10 than $5 per kilowatt.

In addition to reducing investment, semi-outdoor plants economize in use of materials (particularly important during the war) and make possible greater speed in construction; also, because of compact and convenient layout, they permit use of a relatively small operating staff.

It is realized that there are wide differences of opinion as to advisability of adopting this type of design; that conservatism, pride in architectural appearance, and other intangibles are powerful influences; and that as yet relatively few executives or designers consider it expedient to take advantage of savings made possible by semi-outdoor arrangement.

In Fig. 1 is shown an example of a recent 30,000-kw semi-outdoor plant, supported on a slab at ground level. The building frame is of reinforced concrete, adopted to save steel during the war emergency. The steam generator, including air heater and draft fans, is placed outdoors, with concrete slab over boiler. The turbine-generator is protected by a light metal housing, removable in sections, placed on an open deck above the condenser enclosure; and a gantry crane handles turbine and other machinery parts. Generator leads pass overhead to a nearby step-up substation, connecting directly to a 110-

* Condensation of talk presented by Mr. Friend before Metropolitan Section, A.S.M.E., March 13, 1946.

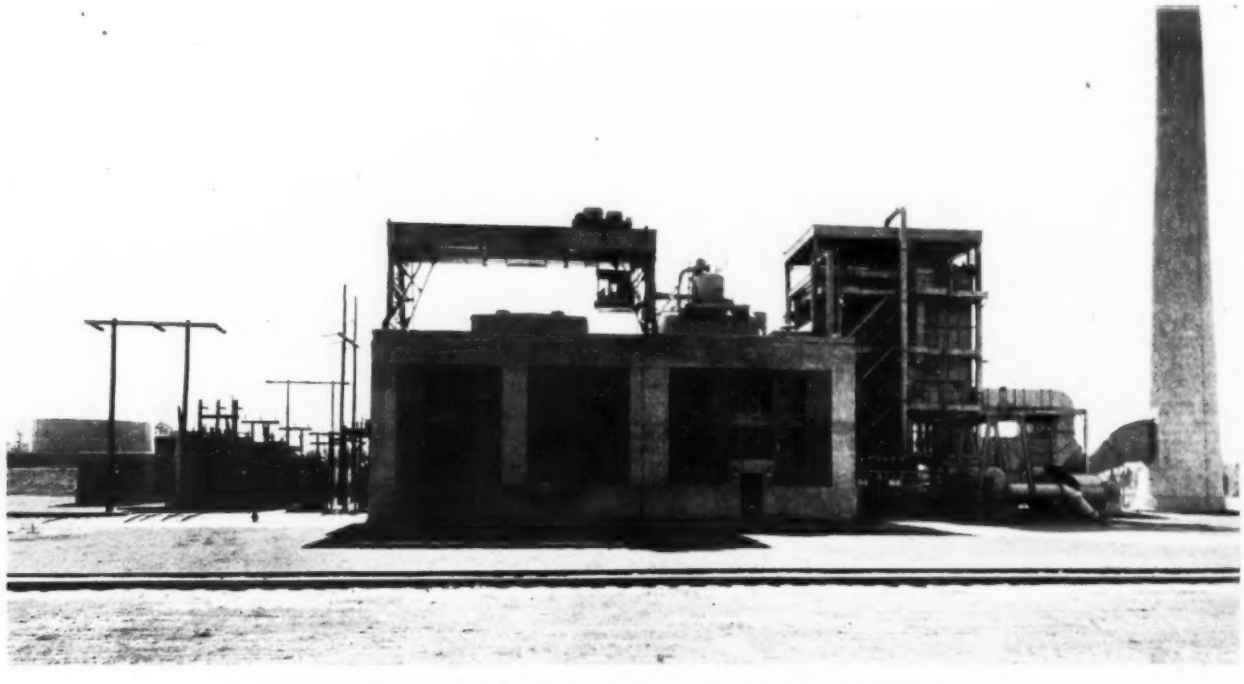


Fig. 1—Harvey Couch Station of Arkansas Power & Light Co.

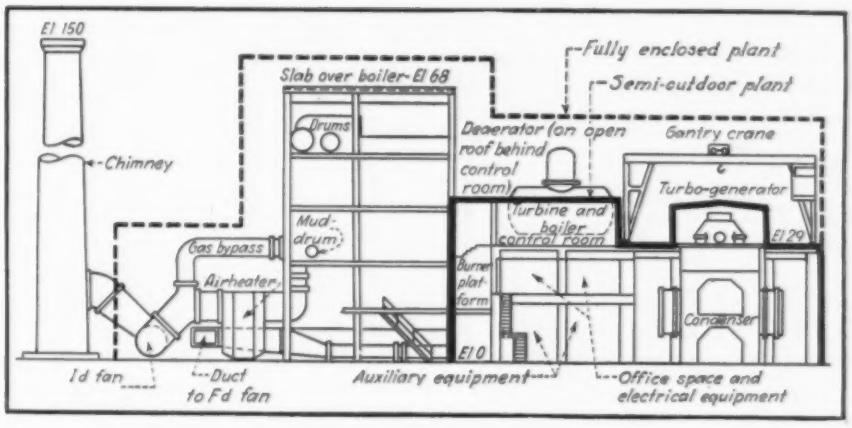


Fig. 2—Arrangement of equipment in station shown in Fig. 1

kv transmission line. This station, as do many in the Southwest, uses cooling towers for condensing water, and obtains makeup from wells.

A good idea of such general station design is afforded by study of Fig. 2, which is a section of the plant illustrated in Fig. 1. At right is the turbine on open deck, with condenser beneath and gantry crane above; at left is the natural-gas-fired steam generator, with housing provided for firing aisle. Adjacent to the firing-aisle housing is a central control room, for turbine-generator, boiler and electrical circuits. Deaerating heater is located on roof, behind the control room. Lower floors of the auxiliary bay provide office space and housing for auxiliary equipment.

The section further illustrates saving of building volume that may be realized by semi-outdoor design. Area enclosed by solid line, shown inside dotted outline, indicates the proportionately smaller space occupied by a semi-outdoor plant as compared to a minimum fully housed design of same capacity.

An Economic Problem

There are in general two viewpoints in design of steam plants. Many engineers take the position that, in considerable measure irrespective of investment incurred, a steam plant must be of the best possible character, obtain highest practicable efficiency and reliability, and present a dignified architectural appearance.

There is a growing number of design engineers who believe that the most important criterion in selecting a design of plant is overall economy—that is, lowest total cost of power and energy, consistent with good reliability. Cost of energy is largely made up of fixed charges on investment, taxes and energy production costs. In the last-mentioned, consideration must be given to maintenance expense, and to service-demand availability of equipment. It goes without saying that under usual conditions of public-utility service, good dependability must be assured.

This economy policy has been the most important guide, in working out plant designs, of the engineering organization with which the writers are associated. Saving in cost of energy produced by utilities is becoming more and more important as the years go on, considering rising costs of plant and attendance, the ever-present competition of private industrial plants, and the increasing competition of public power. In public power projects a total of 4 to 5 per cent may be assigned as fixed charges on investment, including cost of money and allowance for depreciation; sometimes a minute allowance is made for tax equivalent. A privately owned utility may need to figure 11 to 13 per cent for fixed charges and taxes; Federal income tax by itself (at 38 per cent on net income) usually figures over 2 per cent of investment.

The question may be asked, for example—will it pay to save $250,000 on investment cost in a given steam plant of say 30,000 to 40,000 kw capacity, by adopting semi-outdoor design as against the conventional fully housed design? What penalties should be assessed against that type of plant, as compared with one of conventional design, in operation and maintenance?

There is little, if any, difference in fuel efficiency or in cost of maintenance. At certain times, maintenance work may have to be done under exposure to bad weather conditions, taking more time than if better protection were available, with resultant higher cost and longer outage of equipment. Such additional expense is in considerable measure counterbalanced by reduction in maintenance of structures, and is in any event not a large item.

As to operating labor, any advantage lies with the simpler and more compact type of station, with minimum distances between pieces of operating equipment and minimum structural interference. Size of operating forces used in a number of semi-outdoor plants is touched upon later. Certain features permitting convenient and rapid construction are also discussed.

Not all charges and credits against energy cost, considered in comparing types of plant, are assessable directly in dollars per kilowatt-year or in mills per kilowatt-hour of output, but this can be done in large measure. In short, therefore, it appears that there is a very small, if any, dollar penalty incurred in production costs by adoption of semi-outdoor design, and that investment saving is therefore substantially net.

Considerations Affecting Use of Outdoor Plants

It may be considered as somewhat easier to adapt outdoor design to small or moderate-sized plants. The compact arrangement lends itself admirably to a single-unit or two-unit plant up to perhaps 100,000 kw in size; however, it may be carried up to any size desired.

It is also easier and simpler to utilize outdoor equipment if gas and oil fuel are used, rather than coal; because in handling coal in freezing climates, enclosure of

more space is required than for firing gaseous and liquid fuels only. However, outdoor or semi-outdoor boilers, pulverized-coal fired or stoker-fired, are practicable in freezing climate if proper protective measures are taken.

With regard to appearance of plant and structures, it is felt that a power station should present a workmanlike whole, indicating function rather than presenting architectural elaboration. Given proper external treatment, modern steam generators, with their associated equipment, can be made to present a workmanlike appearance. After all, the plant is a "kilowatt-hour factory," *and there seems little justification for spending more than the minimum necessary to assure good proportions* and acceptable appearance.

An important element in design of present-day plants, whether for production of electric energy or of materials or equipment, is that working conditions shall be reasonably good, suitable measures being taken to protect employees against extreme conditions of noise, dust, bad air, heat, cold, and exposure to the elements. This does not mean, however, that power-station operators should never have to go outdoors, or should never be exposed to the weather. Outdoor work is necessary in steel mills, oil refineries and many other industries, in land and marine transportation, and in operation and maintenance of overhead and underground power lines.

The semi-outdoor type of plant is admirably adapted for providing comfortable and sanitary conditions for operators, in the performance of practically all operating functions and in most maintenance work. Some of the maintenance, as is evident, must be performed in the open.

Outdoor-Type Structures

Thirty or forty years ago practically all substation equipment was housed. However, beginning in the "teens," transformers and oil circuit-breakers were installed outdoors, and at present very little high-voltage equipment is housed.

Similarly, up to 1910 or 1915, hydroelectric generators were installed indoors. At that time the writers' associates laid out a new design of plant, using so-called umbrella-type generators, with a low housing over them, the parts to be handled by an outdoor gantry through hatches in building roof. The design is now quite commonly used, and stations of that type are in operation all over the country, north and south.

Oil-refinery equipment and structures constitute an excellent example of what economies outdoor installation, operation and maintenance may bring, when applied to a plant that would be impossible, economically, to house. Pressures and temperatures in oil-refining practice are frequently much higher than those experienced in steam power stations. *A great deal of pipe-line pumping equipment is installed outdoors, in various parts of the country.*

Much important equipment in manufactured-gas plants, steel mills, chemical works and other industrial plants is placed outdoors, for economy and convenience.

Steam-Electric Stations

Table 1 gives certain data with respect to fifteen semi-outdoor steam electric stations engineered for clients during past ten or twelve years. Dates of initial operation range from 1936 to 1945 for the completed plants, and to 1947 for those under construction. Aggregate net capability is between 500,000 and 600,000 kw. Pressures and temperatures range up to 1250 psig, 950 F.

TABLE 1—SEMI-OUTDOOR STEAM ELECTRIC STATIONS—SUMMARY OF PRINCIPAL DATA

Station				Throttle Conditions		Turbine-Generator Equipment			Steam-Generator Equipment			
Location	Name	Start of Operation	Approx. Max Net Output, Kw	Psig	F	Number and Make	Weather Protection (*B*)	Condensing Water Source	Number and Make	Max Continuous, M Lb per Hr, Each	Base Fuel	Weather Protection (*C*)
Utah	Orem	1936	17,000	400	750	1—GE	*l*	River	1—C-E	200	Bit. coal	*s*
Nebraska	South Omaha	1938	(*A*) 6,000	450	750	1—GE	*i*	(B-p turbine)	2—C-E	200	Nat. gas	*h*
Kansas	Ripley	1938	25,000	650	825	1—West	*i*	Cooling tower	2—C-E	160	Nat. gas	*h*
Texas	Mountain Creek	1938–45	60,000	650	825	1—AC, 1—GE	*i*	Lake	2—B & W 1—B & W	200 300	Nat. gas	*o*
Texas	Gable Street	1938	25,000	850	900	1—GE	*i*	Cooling tower	1—Riley	250	Nat. gas	*h*
Florida	Miami Beach	1942	30,000	850	900	1—West	*i*	Ocean bay	1—C-E	300	Oil	*h*
Carolina	Cape Fear	1942	60,000	850	900	2—West	*i*	River	2—Riley	330	Bit. coal	*h*
Arkansas	Harvey Couch	1943	30,000	650	825	1—GE	*r*	Cooling tower	1—C-E	350	Nat. gas	*s*
Texas	West Junction	1943–47	70,000	850	900	2—GE	*r*	Cooling tower	2—Riley	400	Nat. gas	*s*
Louisiana	Sterlington	1943	40,000	850	900	1—GE	*e*	River	1—C-E	425	Nat. gas	*h*
Florida	Sarasota	1946	17,000	850	900	1—GE	*l*	Ocean bay	1—B & W	200	Oil	*o*
Florida	Riviera	1946	40,000	850	900	1—West	*l*	Ocean bay	2—B & W	250	Oil	*o*
Arkansas	Cecil Lynch	1946	30,000	850	900	1—West	*m*	Cooling tower	1—C-E	325	Nat. gas	*s*
Louisiana	Industrial Canal	1947	35,000	1250	950	1—GE	*m*	Naviga canal	1—F-W	400	Nat. gas	*s*
Texas	Handley	1947	40,000	850	900	1—West	*m*	Cooling tower	2—B & W	230	Nat. gas	*o*
			525,000			18			23			

(*A*) Back-pressure turbine supplying steam to industrial customers.
(*B*) Weather protection for turbine-generators designated as:
r—Open deck and gantry crane, with removable housing.
m—Open deck and gantry crane, with masonry walls and roof hatches
e—Open deck and existing indoor crane on extended runway, with masonry walls and roof hatches.
l—Gantry crane over low turbine room, with roof hatches.
i—Conventional turbine room, with indoor crane.
(*C*) Weather protection for top of steam generators designated as:
o—Open with rainproof casing only.
s—Open with concrete slab above unit.
h—Hood enclosure or canopy surrounding drums or upper portion of unit.

Location of most of the plants is in southerly portions of country, a good deal of design work for clients being for properties in that region. However, one is in Utah at 5000 ft elevation, with sub-zero temperatures and much snow, and two in Nebraska and Kansas, also subject to very low temperatures. Many of the southern plants are subject, under certain weather conditions, to extreme cold and snow, and in the deeper South to torrential rains.

A large majority of these stations use gas or oil fuel. One of the coal-fired, the first in the list, offers an example of low unit cost for a complete low-capacity installation—less than $65 per kilowatt.

For the plant shown in Fig. 3, one of the earlier of the semi-outdoor type, a fully housed turbine room was adopted. The gas-fired integral-furnace boilers are

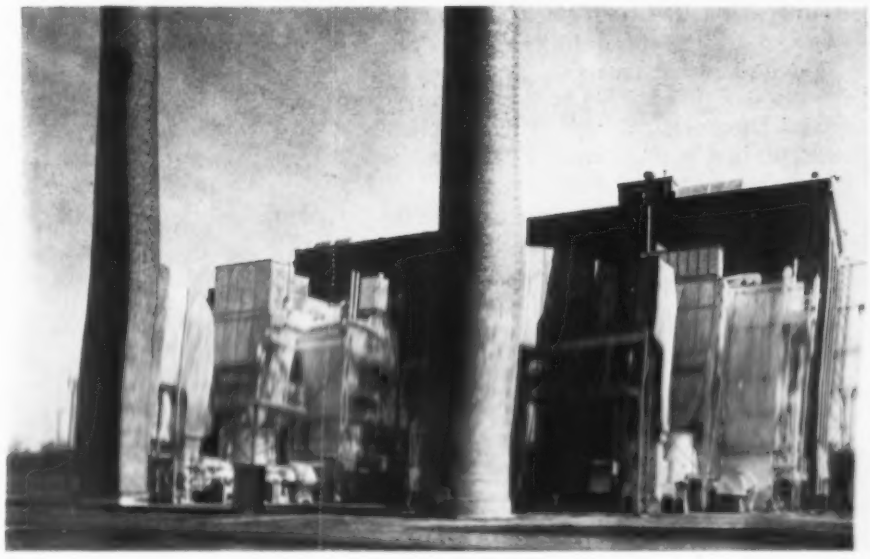
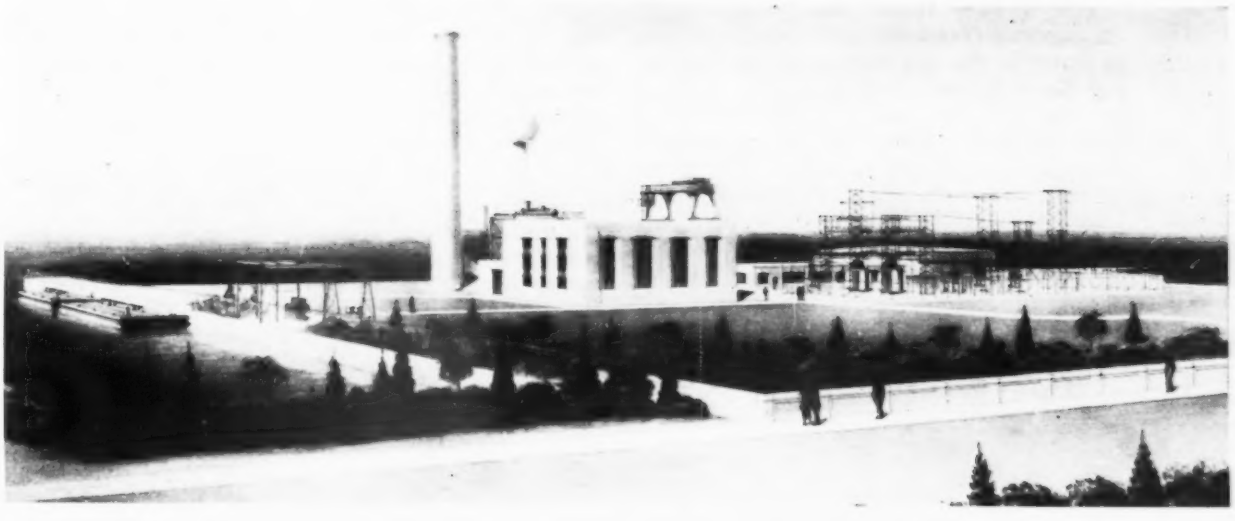


Fig. 3—Mountain Creek Station of Dallas Power & Light Co., as of February 1, 1946

Fig. 4 (left)—West Junction Station, Houston Lighting & Power Co., Texas

Fig. 5(below)—Architect'sketch of Sarasota Station of Florida Power & Light Co., 1946



housed only at the firing ends. Boiler roof casings are welded, to give weatherproof construction. Location of air heater and draft fans is quite typical for plants of this type. The illustration shows the station as recently extended. As design for the first unit proved entirely satisfactory, the original layout is practically duplicated, except that a single steam generator is installed with the second turbine.

Fig. 4 shows one of the more recent stations, designed for 850 psi, 900 F, not only with outdoor steam-generating equipment, but with the turbine-generator installed in a sectional housing on an open deck, condenser beneath and gantry crane above. As is general practice with low housings enclosing the turbine-generators, ventilation is by forced air. It is also becoming practice to apply an insulating covering to certain portions of the turbine enclosure, to reduce noise as well as heat transfer. The original installation at this site, which has been operating about three years, was considered so satisfactory by executives and engineers of the power company, that construction is now under way on a nearly identical extension.

The 850-psi, 900-F station illustrated in Fig. 5 has recently been put in operation. This architect's sketch shown gives a better idea of arrangement than any photograph obtained to date. The plant is in a "vacation" city in Florida, and because of location it was necessary that appearance be pleasing. There is therefore somewhat greater elaboration in architectural features than in other plants of this type; for instance, a turbine housing of full width of condenser enclosure is used, instead of a narrow housing. This installation shows some of the possibilities of obtaining a pleasing exterior, while retaining many of the benefits of semi-outdoor construction.

At the plant shown in Fig. 6 are two 850-psi pulverized-coal-fired steam generators, installed in semi-outdoor fashion with firing aisle housed. In this case the existing turbine room was extended to take two 30,000-kw units. The view shows one of the boilers, before painting and improvement of details.

Fig. 7 shows an 850-psi installation of the newer type, built as an extension to a 300-psi older-type fully housed station. The steam generator is outdoors with firing space practically inside the old boiler house. Possibly a better looking enclosure might have been designed for enclosing the drum. The existing turbine-room crane passes through a slot in the end wall of the old turbine hall, crane rails being carried on bents. Low turbine housing in this case has permanent masonry sides and roof, access for handling machinery parts by crane being through roof hatches. As compared with conventional extension of turbine room, the design shown saved approximately $100,000.

The station illustrated in Fig. 8, also designed for 850 psi 900 F, is under construction. Cooling towers are used, although it would have been possible to build the plant on a neighboring river, at considerably increased expense. In this case the client desired to include space as shown, for storeroom, machine shop and other uses, instead of utilizing a separate building.

Major Equipment

There has been good cooperation from manufacturers in the development and installation of outdoor and semi-housed equipment. Indeed, General Electric Co. has itself done pioneering work in outdoor installation of turbines. A steam turbine was in the early 1930's installed out of doors in the mercury-steam plant at Schenectady. Steam-generator manufacturers have likewise been cooperative, and designs have been prepared for outdoor installation of a number of major makes of boilers. The B & W type "F," for instance, with welded casing, needs little or no protection from the weather, except at the firing end. Combustion Engineering "VU" boilers and some of the larger C-E types, and Foster-Wheeler and Riley units, are readily installed outdoors, usually protected at the top by a horizontal slab, with sides and back of the unit entirely open. In some cases, upper steam drum or drums are enclosed in a small housing, and in other situations only the drum ends are protected, covering gage glasses and other details. Safety valves are preferably protected from the weather, in some cases by a small separate housing, but this has not always been found necessary.

Indeed, steam generators are usually adaptable, without difficulty, to installation in an outdoor or semi-outdoor fashion. The modern boiler is of itself a large cased structure, easily weatherproofed. Considering the heat radiated, there is an advantage in having this dissipated into outdoor air rather than having to handle it by ventilating fans, in maintaining livable conditions in an enclosed boiler house. Then, too, the boiler house is usually the largest and highest structure of all those composing the station building, and the saving by omission of a large part of this housing is very substantial. In addition, protection against weather for such equipment as air heaters, and forced- and induced-draft fans, has been well worked out. Frequently, outdoor arrangement of such equipment—as has been illustrated—enables placing it on the ground rather than at top of the steam-generator structure.

With respect to turbine-generators, so far as is known only the generator end has up to the present time been installed unhoused—with the exception of the turbine at Schenectady. However, designs are offered by one or more manufacturers for complete outdoor turbine-generators. The present-day tendency to provide good-looking functionally styled metal lagging for all working parts furnishes protection to a considerable extent. It may be that for some time to come the steam turbine—at least the high-pressure end—will be protected by some housing, and the generator may be left outdoors, in a manner similar to that followed in a number of cases with synchronous condensers.

Several of the turbine-generator installations shown involve the use of a light removable housing protecting the entire unit, or a low structure with permanent side walls and roof, and roof hatches. In case of a sectional light removable structure, any number of sections can be removed by the crane, depending on the part of unit to be handled. All turbine parts can be handled by gantry crane by removal of sectional housing or of roof hatches, with exception of the generator stator. It is rather seldom, in economical designs, that turbine cranes are expected to lift the generator stator. In a properly designed semi-outdoor plant, ample space is provided for storing of turbine-generator parts during a major overhaul. Most of the minor maintenance is taken care of

Fig. 6—Cape Fear Station of Carolina Power & Light Co.

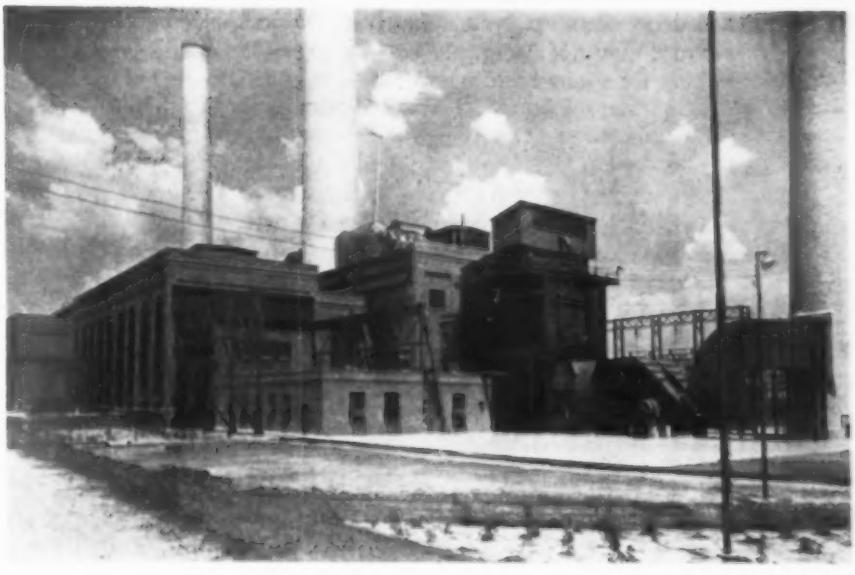
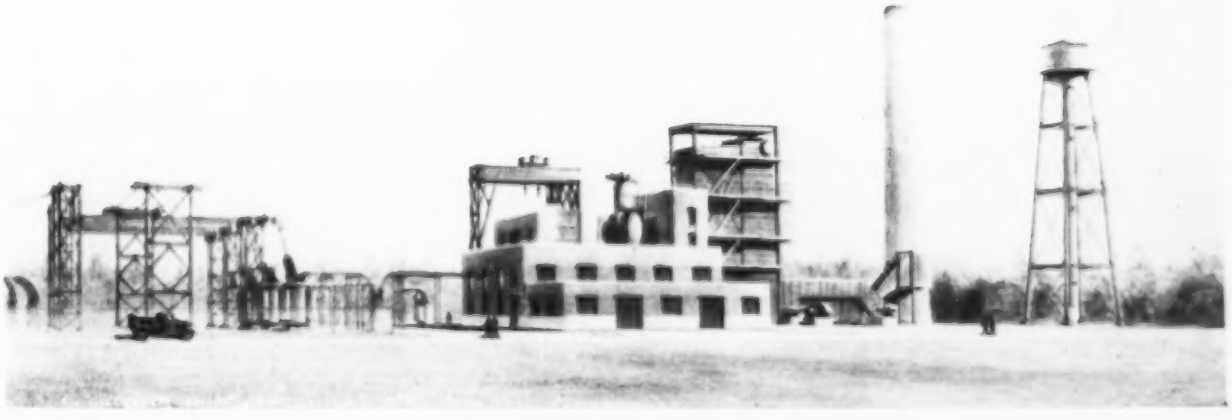


Fig. 7 (right)—Semi-outdoor extension to Sterlington Station of Louisiana Power & Light Co.

Fig. 8 (below)—Architects sketch of Cecil Lynch Station of Arkansas Power & Light Co.



within the low housing, and any large part (except generator stator) requiring work can be lowered into the condenser enclosure. In extreme cases, when heavy maintenance is required during inclement weather, recourse is had to tarpaulins for protection of apparatus and workers.

With respect to equipment in the feedwater system, feed pumps and extraction heaters are normally installed indoors in plants of the type under consideration. The deaerating heater is placed outdoors, on roof of auxiliary bay, obtaining in this way ample head for delivery to feed pumps. The evaporator may also be placed outdoors if desired.

The main steam lead from superheater in a semi-outdoor plant is usually carried outdoors, entering the building at a convenient point on the way to the throttle. Outdoor steam piping is, of course, thoroughly insulated and protected from the weather, the latter frequently by means of a metal jacket over insulation.

No important changes in installation of electrical equipment are required for adaption to a semi-outdoor plant. As is practically always done, for all types of station, high-voltage equipment is placed outdoors. Station auxiliary transformers may be indoors or outdoors—usually the latter—as found convenient. Auxiliary bus and breakers are usually placed in a convenient location indoors. For one plant, however, 2300-volt auxiliary buses and breakers are being placed outdoors. Electric conduits are, many of them, placed in a gravel-filled space between the main building foundation slab and finished ground floor, although this is not peculiar to the semi-outdoor plant.

Investment and Operation

Table 2 shows briefly the major differences between recorded cost of a 30,000-kw semi-outdoor station, adjusted for present-day cost levels, and estimated investment in an equivalent station, completely housed,

TABLE 2—RELATIVE COSTS OF INDOOR AND SEMI-OUTDOOR TYPES OF STATION BUILDING

Approximate tabular figures are for a 30,000-kw plant, with same arrangement of equipment in both cases. Costs are based on 1946 price level. All elements of plant in which a significant cost differential obtains are included; differentials arrived at are therefore for station as a whole.

	Indoor	Semi-Outdoor	Saving
Substructure	$ 80,000	$ 70,000	$10,000
Structural frame	150,000	85,000	65,000
Walls	45,000	15,000	30,000
Floors	20,000	15,000	5,000
Roofs	50,000	15,000	35,000
Doors and windows	25,000	10,000	15,000
Painting and finishing	20,000	10,000	10,000
Building equipment	70,000	55,000	15,000
Crane	40,000	50,000	−10,000
Weatherproofing of equipment	.....	15,000	−15,000
Material and labor	$500,000	$340,000	$ 160,000
Overhead and undistributed costs, 15%	75,000	50,000	25,000
Total of items affected	$575,000	$390,000	$ 185,000
Unit cost, dollars per kw	19	13	6

with walls carried to a point above station crane and around the steam generator, and with an indoor crane substituted for the gantry. In the plant with reduced structures, as shown, cubic contents of building are about one-third, and total steel tonnage is something over one-half, of corresponding quantities for the fully housed plant. Estimated saving is approximately $6 per kw.

It would be fairer to compare costs of a semi-outdoor station with those of a plant specifically designed as of the completely housed type, although this is more difficult, because many adjustments are usually required to bring the two constructions to reasonable parallelism. Such alternative comparison would, we believe, show a wider cost differential between the housed and semi-housed designs.

As to maintenance costs, there is no significant difference between a simple type of fully housed station and one of semi-outdoor construction, although the expense for building maintenance for an elaborate conventional station will be much greater. As stated earlier, fuel economy should be practically the same for the two types of plant.

Operating Labor

A comparison of operating costs as between the two types of station also presupposes reasonable definiteness in design of each. For a 30,000- to 100,000-kw semi-outdoor plant with one or two units, all control boards can be placed in one room, so that one operator can attend to turbine-generator and steam-generating equipment, as well as electrical circuits. A fully housed plant may approach the semi-outdoor with regard to compactness of controls and convenience in operation. It appears increasingly desirable to limit the operating force to a relatively few skilled operators.

As illustrating the economies practicable with respect to operating force, a 35,000-kw gas-fired single-unit plant of this character, which has been in operation for several years, requires a total of 18 operators for all shifts. This is on a 40-hr basis—the equivalent of about four shifts daily, requiring on the average of about four men per shift, including supervision. In this case, maintenance men are drawn from a system "pool." If these men were to be allocated to the plant, it would add five or six to the staff. It is expected that, with a second unit now going in, giving 70,000 kw total capacity, from four to six operators will be added to the force. Another gas-fired plant of 30,000-kw capacity, is credited with 23 men, including four for office and supervision, 14 operators and five maintenance men.

Conclusion

The design of this type of station is in a development stage, and there will doubtless be many variations brought out. Just what form they will take it is impossible to predict. A possibility, however, is that the entire turbine-generator and condenser beneath or at the side, will be left unhoused. For the most part, in climates involving inclement weather, some housing will be provided for personnel while performing most operating functions and at least minor maintenance work, for principal instruments and controls, and for the more delicate equipment. Experience acquired in operation and maintenance work will be taken advantage of, for development of still better and probably lower-cost installations.

It is believed that the economies and general benefits here discussed will be given more and more consideration as time goes on, and that instead of remaining the exception, semi-outdoor construction for utility and industrial steam plants, over a wide range of sizes and under the majority of climatic conditions, will gain growing acceptance.

Evaporators and Their Operation

By GEORGE A. FRICKE

The Griscom-Russell Co., New York

Evaporator applications are discussed broadly; diagrams showing typical layouts of single- and multiple-effect arrangements are included; and detailed operating instructions are appended for the bent-tube, submerged, scale-shedding type of evaporator.

ALTHOUGH evaporators have various applications in industry, power engineers are concerned chiefly with their use for producing distilled boiler feed makeup, and occasionally as a source of low-pressure process steam. Also, in the marine field evaporators are generally employed to furnish distilled water for boiler makeup and for other ship use, from sea water or from bunkered fresh water.

Such evaporators are usually of the submerged-tube type; that is the steam is supplied to tubes surrounded within the shell by the water to be evaporated. The temperature difference between the condensing steam and the vapor generated from the feed is a primary factor affecting the capacity of the evaporator. The source of the evaporating steam is usually exhaust from auxiliaries, steam bled from the turbine, or occasionally live steam.

The simplest type of evaporator is the "single-effect." Where two or more evaporators are connected in series, so that the vapor from one is employed as the heating steam for the next, the arrangement is designated as "multiple-effect." For a given amount of required makeup, the quantity of heating steam, as well as the amount of heat that must be returned to the water cycle by condensation of the evaporator vapor, decreases with the number of effects employed. In other words, the multiple-effect means lower consumption of steam to produce a given quantity of distilled water. However, the greater the number of effects, the higher the initial cost of the installation. Where the required makeup is low, say around 2 per cent or less as in many central stations, a single-effect is usually employed, because the relatively small heat returns can be readily absorbed between the extraction heating steps of the turbine by the boiler feed available. When conditions are such as to require a large percentage of makeup, multiple-effect evaporators are justified. They are quite generally employed in marine practice.

For most economical results the evaporator system should be fitted into the heat balance of the plant, bearing in mind the interrelation of heaters, economizers, turbines, auxiliaries and condensers.

In smaller plants that have a relatively simple heat balance, the evaporators may be arranged on the vacuum system—either low-heat level or high-heat level. Fig. 1 represents a single-effect vacuum system in which the raw water for boiler makeup is supplied directly to the evaporator which receives steam at low pressure or under vacuum. The evaporator vapor is produced below atmospheric pressure and is condensed in an evaporator-condenser by the condensate from the main turbine. Thus the heat returns from the evaporator are absorbed by the turbine condensate.

A low-level, two-effect system is illustrated in Fig. 2.

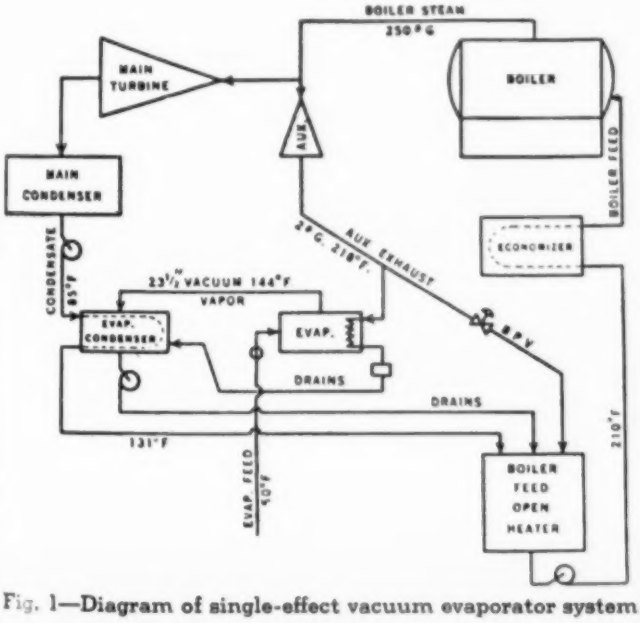


Fig. 1—Diagram of single-effect vacuum evaporator system

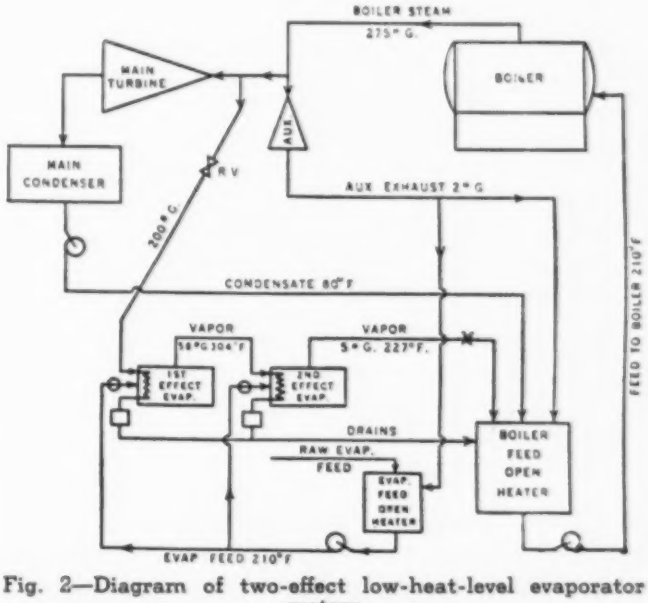


Fig. 2—Diagram of two-effect low-heat-level evaporator system

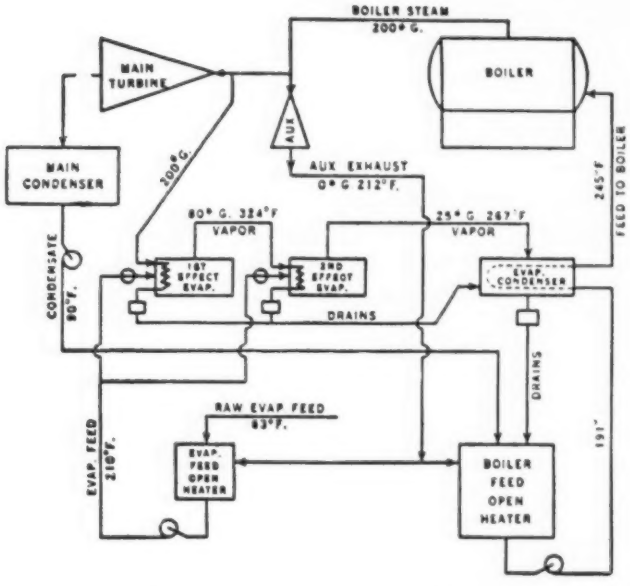


Fig. 3—Flow diagram of two-effect high-heat-level evaporator system

Here the raw evaporator feed is preheated in an open heater employing exhaust steam from the auxiliaries. The vapor from the second effect, as well as the drains from both effects, is led to an open boiler-feed, or deaerating, heater which also receives the condensate from the main condenser.

A two-effect evaporator, operating on the high-heat-level principle is shown in Fig. 3. In this the evaporator feed is preheated, as in Fig. 2, but the steam is supplied at high pressure. The high-temperature evaporator vapor from the second stage is condensed in an evaporator-condenser by hot water from the deaerating heater. With this arrangement, which is adaptable where there is considerable differential between the temperature of boiler steam and that of entering feedwater, the open boiler-feed heater is free to condense a greater amount of auxiliary exhaust because the evaporator returns are absorbed at a higher heat level.

In many large plants the evaporators are arranged interstage; that is, each evaporator and its condenser is located between two consecutive stage heaters. A typical arrangement is shown in Fig. 4. With such a system each turbine provides its own share of the makeup and the total makeup capacity is greater than with a single high-heat level evaporator supplying all the makeup for several units.

In central heating plants and some industrial plants where the boiler makeup is very high, heating or process steam may be required at lower pressure than that used for the main units or auxiliaries. In some such cases it may be found advantageous to employ evaporators, serving as reducing valves, with part of the evaporator output producing low-pressure steam and the remainder condensed for distilled boiler makeup.

Operation of Evaporators

As with all classes of power plant equipment, minimum maintenance is achieved and fewer operating troubles encountered if operating instructions for the particular equipment are closely adhered to. Instructions covering the operation of "Bentube,"[1] scale-shedding submerged type evaporators developed by the Griscom-Russell Co. are given below. The tube bundle of such an evaporator with initially bowed elements is shown in Fig. 5. In this design the heating elements do not require periodical removal of scale accumulations by hand as this is accomplished by thermal cracking.

Before Starting

Examine the piping, valves, gages, etc., to become familiar with the location and purpose of each.

See that all safety and relief valves are in place.

A hydrostatic test of the entire system will indicate any leaks which would interfere with operation or be dangerous when steam is turned on. To test for possible leakage of tube joints or leakage at the shoulder plugs, apply the hydrostatic pressure on the shell side. The appearance of water in the evaporator drainer gage glass will be an indication of such leakage.

It is good practice to test all evaporator vapor condensers (high-pressure and vacuum types) for tube leakage. This may be done by closing the inlet vapor and drain valves and passing the circulating water through the tubes at normal operating pressure. Any leakage would show up in the drainers or hotwell. To locate a leak it is necessary to take off the water heads while there is water pressure in the shell.

With the steam valve to the direct-contact deaerating heater closed, open the feed valve to the heater so that the feedwater will enter the shell through the automatic feed-control valve. See that the bypass of cold water direct to the evaporator feed pump suction is closed.

Open the suction valve to the evaporator feed pump.

Open the main feed valve on the evaporator.

Try out the evaporator feed pump to see that it is working properly, draining the water from the evaporator though the blowdown valves. Shut down the pump and drain the water from the evaporator to 5 or 6 in. below the normal operating level indicated on the setting plans of the evaporators.

[1] Copyrighted term to designate this particular design.

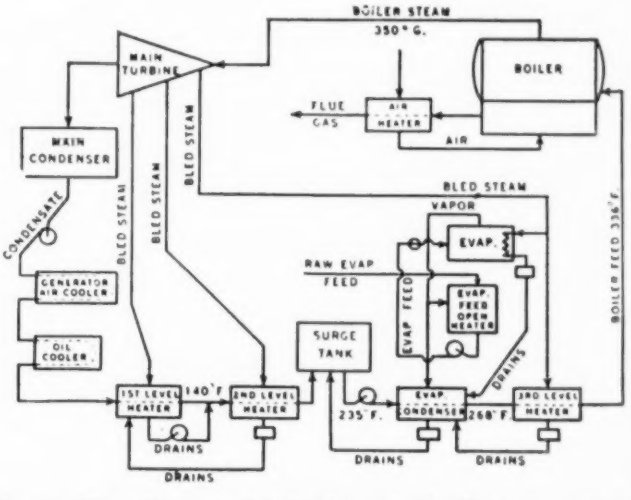


Fig. 4—Flow diagram of interstage single-effect evaporator, with condenser-type heaters utilizing steam bled from three turbine stages

Starting

With the main steam valve closed, set all other valves to pass steam, vapor, condensate and circulating water from unit to unit. The special water and steam valves for cracking scale should be closed. The valves on the drainers should be set to pass the drains through the balanced valves. All air vents should be wide open.

Crack the main steam valves to the evaporators to carry about half the steam pressure necessary for full operation. For the first few days or weeks of operation, depending on the quality of water used, the evaporators would produce considerably more vapor than required if the full steam pressure were carried in the tubes, due to the cleanliness of the tubes. If this excess capacity were permitted the evaporators might prime in some instances; i.e., if the units were operated at a greater capacity than that for which they were designed, a part of the feedwater might be carried over with the vapor and the distillate

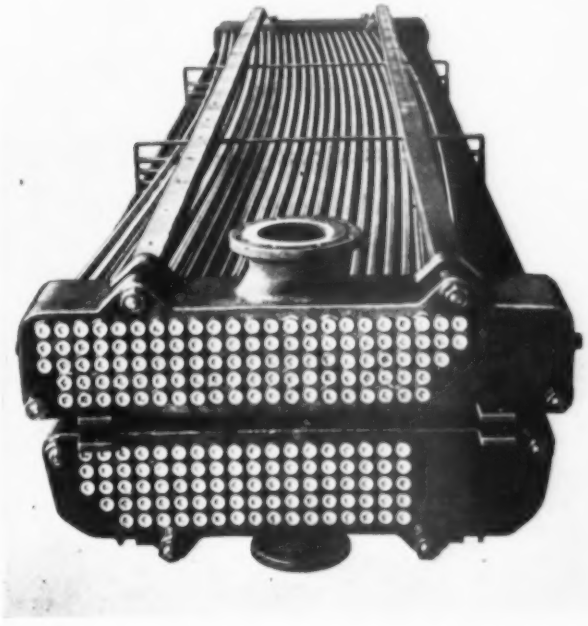


Fig. 5—End view of "Bentube" evaporator tube bundle, showing initial curvature of elements

would be impure. There is a particular tendency to priming if the feedwater is brackish, over-treated or contains a high percentage of solids.

After a few days or weeks, the tubes will become coated with scale and the steam pressure should be gradually increased to maintain the desired capacity.

Do not attempt to control the capacity by lowering the water level to reduce the effective tube surface. When some method of control of the output must be used, it is preferable to install a back-pressure valve or, when possible, a properly designed orifice plate in the vapor line.

Water Levels

When the water in the evaporator begins to boil, start the evaporator feed pump and set the pump governor or differential pressure regulator, in multiple-effect systems, so that the discharge pressure will be 10 or 15 lb higher than the first-effect shell pressure. For single-effect operation set the discharge pressure at no more than 25 lb higher than the shell pressure, as greater differential pressures tend to cause chattering of direct-lever-operated valves which, in turn, wears or breaks the valves. For higher differential pressures, power-operated feeder valves should be used.

Adjust the feeder to maintain the water level shown on the setting plans of the evaporators. The level inside the shells of the evaporators is actually several inches above the apparent level indicated in the gage glasses, due to the boiling in the shells.

Water levels will vary considerably with operating pressures and with water quality, but in all cases the level must be kept high enough to permit the boiling water to cover all the tube surface.

Adjust the float-controlled valve on the deaerating heater to maintain the water level indicated on the setting plan.

All float-controlled valves, as well as the pump governor, should receive final adjustment when the units are operating at normal capacity.

Air Venting

Thorough air venting of all units at all times is of primary importance. Lack of sufficient air venting may reduce capacity considerably. When the air vents begin to blow steam, the vents in the evaporator vapor nozzles should be closed tight and all other vents should be partly closed, but should be left open sufficiently to blow a small amount of steam continuously.

The deaerating heater should be vented thoroughly or deaeration will not be accomplished.

The vapor generated in the evaporator will be contaminated with quantities of carbon dioxide gas and provision should be made to vent thoroughly all units into which the vapors are discharged. Where possible, it is desirable to take all the heating steam for the deaerating heater from the evaporator-condenser vents.

Superheat

Steam temperatures above 450 F are not desirable due to the detrimental effect upon the grain structure of Admiralty or copper tubes which are commonly used in evaporators. When high superheat is encountered proper means for desuperheating should be provided.

Blowdown

When submerged-type evaporators operate with fresh water feed (containing not over 100 gr per gal of total solids), it is usually not desirable to have continuous blowdown since the intermittent blowdown incident to scale cracking is sufficient. In general, fresh-water evaporators are designed to operate with a maximum concentration of about 250 gr per gal in the shell.

With sea water feed, it is necessary to operate with continuous blowdown, after the first half hour or so. The evaporators are designed to operate at a maximum concentration of about 4000 gr per gal but it is preferable to maintain a density of not over $1^1/_2$ thirty-seconds in the shell. The amount of blowdown for 1 thirty-second feed should be about 100 per cent of the vapor produced in pounds. This blowdown is accomplished by simply opening a $^3/_4$-in. or 1-in. auxiliary blow valve. A salinom-

eter should be provided for making frequent determinations of salinity in the shell, the salinometer indicating the density of the sample on the proper temperature scale. After a little experience, the operator will be able to adjust the auxiliary blow line to maintain the desired concentration.

The results of insufficient blowdown are: increased tendency for the evaporator tubes to become coated with scale; increase in the tendency to prime or boil over; reduced capacity; and decrease in the life of the interior parts of the evaporators.

The actual quantity of blowdown required for any evaporator can be computed from the following formula:

$$b = \frac{f}{m - f}$$

where

b = pounds of blowdown per pound of vapor produced
f = total solids in evaporator feed, grains per gallon
m = maximum concentration desired = 4000 gr per gal for sea water and = 250 gr per gal for fresh water.

To Crack Scale

The general method of cracking scale from the tubes of a submerged-type evaporator is as outlined below. Air agitation lines are generally installed to increase effectiveness of the thermal scale cracking and to remove loose scale deposits from the tube bundle and from the bottom of the shell.

1. Stop evaporator feed pump, or close feed valves.
2. Close steam valves to each evaporator, but do not close the main stop valve which would shut off the steam supplied to the whole system.
3. Close all vapor valves. (It is sometimes satisfactory to leave the vapor valve on the last-effect evaporator open, but all other vapor valves must be closed.
4. Open main blowoff valve on last-effect evaporator and empty the shell. (Open shell-vent valve in vapor nozzle of evaporator to break the vacuum in the shell, if necessary.)
5. Open independent cold-feed valve wide, close blowoff valve on last effect and fill the shell rapidly with cold water to the top of the gage glass.
6. Open bypasses on drainers.
7. Quickly open high-pressure steam valve on last effect, leaving this valve open for about two minutes, then shut off steam supply. To crack heavy scale deposits from the tubes, the pressure should be at least 60 psig. Do not allow scale cracking steam to exceed about 100 psig, but in no case should this steam pressure exceed the maximum working pressure of the evaporator.
8. Close shell vent, then turn on air pressure to agitate water for about one minute (or build up pressure with air when necessary to force water from shell to sewer).
9. Open drain valve and blowdown completely, keeping air agitation on until shell is emptied.
10. Shut off air, open shell vent and refill with cold water and repeat the entire cracking operation at least once more.
11. Open main steam valve to first effect.
12. Start evaporator feed pump and see that valves in main evaporator feed lines are open.
13. Close bypasses on drainers.
14. Close shell vents after all air has been removed from shell and steam begins to generate.

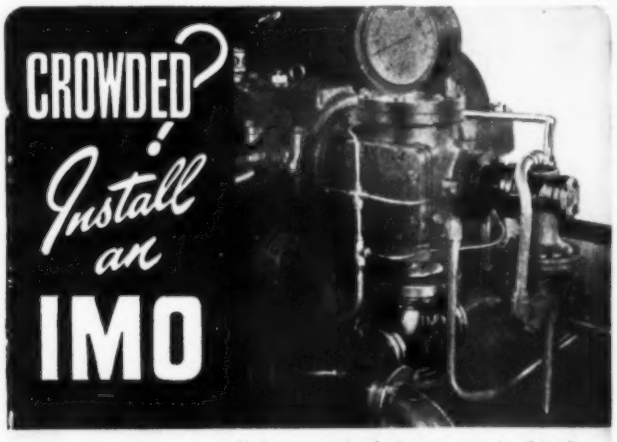
The above method of cracking scale will clean the tubes sufficiently to maintain the capacity guaranteed, if practiced one to three times per day when the evaporators are operating with ordinary fresh water feed. With exceptionally poor feed, the scale-cracking process should be repeated several times at each cracking period, and cracking periods should be at least once every 8 hr. Do not expect to clean the coils completely every time the scale is cracked in this manner. Evaporators are designed to produce the guaranteed capacity with a fair amount of scale on the tubes.

Fig. 5 is an end view of an evaporator tube bundle showing the initial curvature of the elements.

After the operator has become familiar with the method of cracking scale, he will find that it is possible to work on several evaporators at the same time, i.e., one shell can be emptying while the other shell is filling, etc.

The interior of the shells should be inspected at regular intervals (at least once per month), to see that the shell is fairly free from the scale which has been cracked from the tubes.

When the evaporators are shut down for any length of time the shells should be filled with water up to the top of the gage glass.



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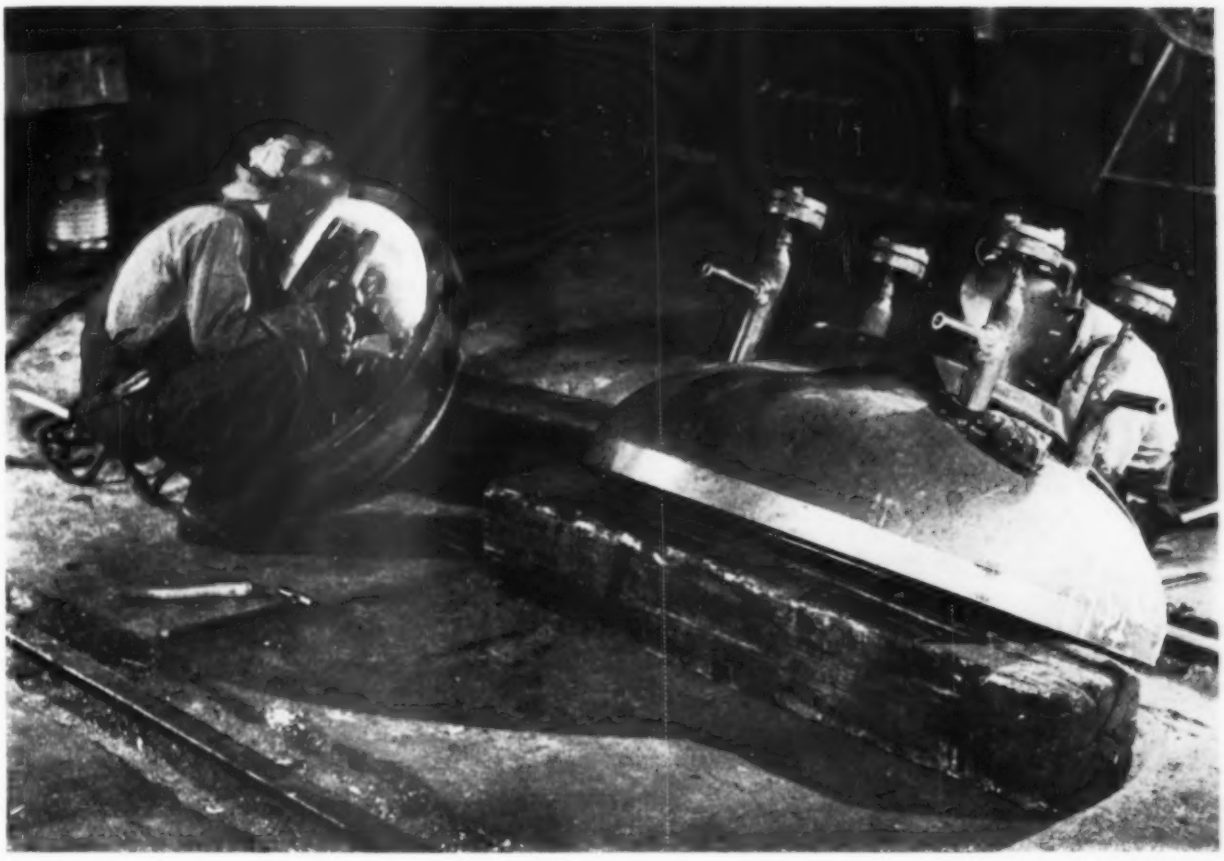

Fig. 1—Welding attachments to high-pressure drum heads

THE FABRICATION OF BOILER DRUMS
Part 2—Welding

This article describes the normal procedure in the metallic-arc method of fusion welding used in the fabrication of boiler drums at the Chattanooga plant of Combustion Engineering Company, Inc. Subsequently, the testing and finishing operations will be described.

By H. R. TOWSE
Combustion Engineering Company, Inc.
Photographs by Author

IN THE fusion-welding process, the work forms one electrode and the weld rod, held in a clamp, either by the operator or by the automatic welding machine head, forms the other electrode. When the arc is struck, the heating effect of the current causes the weld rod metal to flow into the weld groove and fuse with the base metal. The work may be positive (straight polarity) or negative (reverse polarity) depending on the type of rod and the kind of work.

The type of weld rod has a most important relation to this phase of drum fabrication. The shop facilities include a specially designed rod-coating machine and baking oven in which various types of rods may be given different kinds of coatings, depending on the work on which they will be used. This machine also provides the opportunity for immediate weld rod research whenever special problems arise.

Briefly, the purposes and functions of coated weld rods may be stated as follows:

To provide weld metal characteristics equal to those of the base metal and to control the physical and chemical characteristics of the weld bead through the introduction of the required elements in the coating.

To prevent the formation of oxides and nitrides by shielding the arc with an inert gaseous envelope.

To provide a slag covering for the molten weld metal to prevent it from being oxidized and to retard the cooling rate.

Fig. 2—Automatic welding of longitudinal seam. Test plate is shown at end of shell

Fig. 3—Hand welding on boiler shell

Fig. 4—Plates tack-welded to shell will form test plates after longitudinal weld is completed

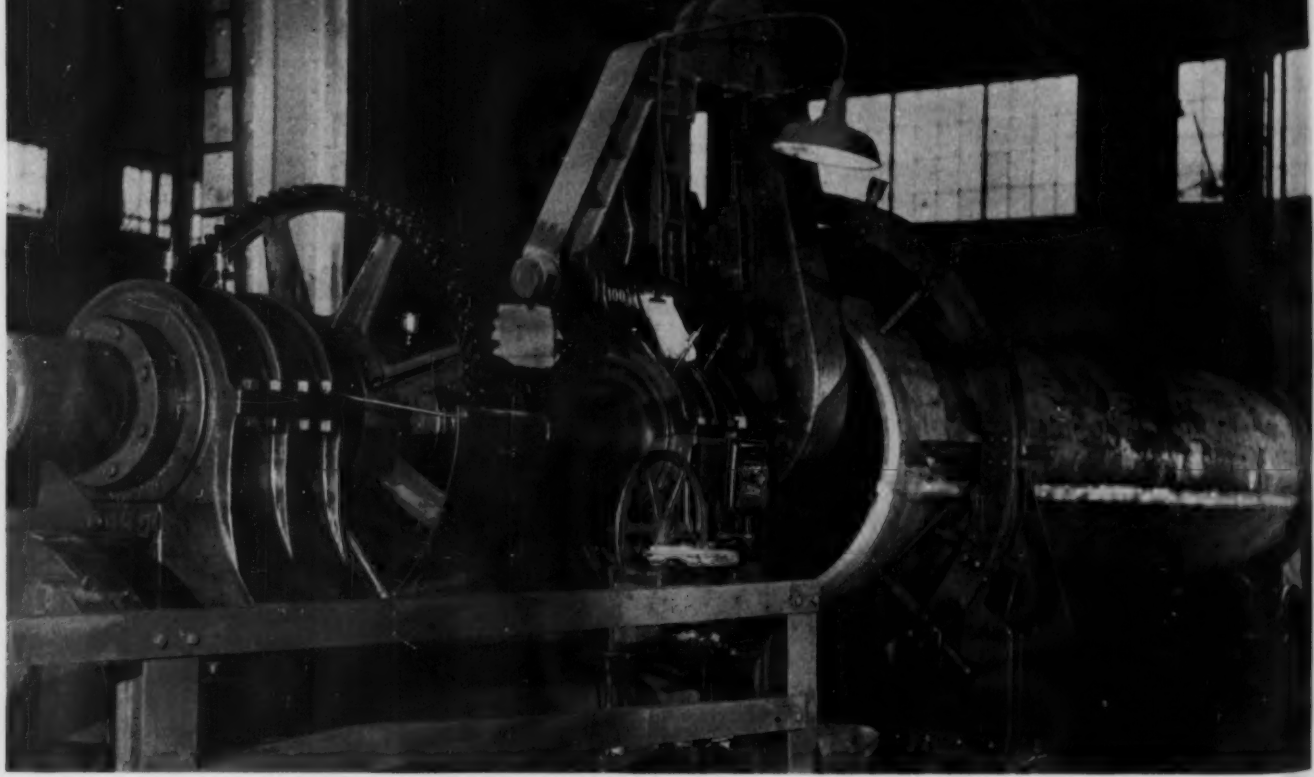

Fig. 5—Ends of shell are machined preparatory to welding on the drum heads

Fig. 6—Welded shell ready to enter million-volt X-ray room

To make it easier to strike and maintain steadiness of the arc.

To obtain greater speed in welding through better arc control and lower thermal losses.

To provide for interchangeable polarity for control of penetration.

The welding operations described herein are the result of the processes, techniques and designs for uniform stressing developed since 1930 in the Chattanooga shops of Combustion Engineering Company. In laboratory tests and in tests with full-sized drums, the welded joints have been proved to have characteristics equal to, or better than, the boiler plate. Furthermore, since the beginning of welding practice in drum fabrication, there have been no failures in the actual operation of thousands of welded boiler drums built by Combustion Engineering for both stationary and marine boilers.

In the first article of this series on the sequence of operations in the fabrication of boiler drums,* the forming and machining of shells and heads were described. After the machining operations on the longitudinal edges of the shell sections are completed, the sections are fitted together and tack-welded on the inside. Then two plates from the same lot of material and of the same specifications and thickness as the shell plate, are tack-welded to one end of one joint of the shell so that the edges to be welded are a continuation and duplication of the longitudinal edges of the shell. The weld grooves are then filled by successive thin layers of weld beads, either by automatic or hand welding, the metal being deposited in the test plate groove continuously and in the same manner as in the longitudinal groove of the shell. At the opposite end of the groove to the one hav-

Fig. 7—Stationary type 400,000-volt X-ray machine. Shell on car moves along a track at side of machine

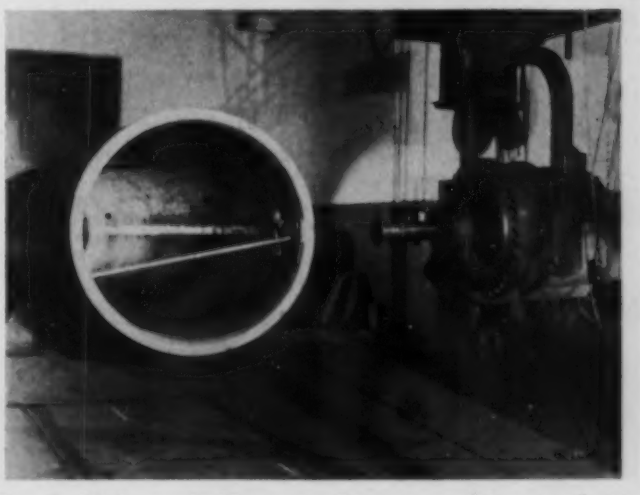

Fig. 8—Million-volt X-ray machine in position to photograph longitudinal seam

* See COMBUSTION, March, 1946, p. 38.

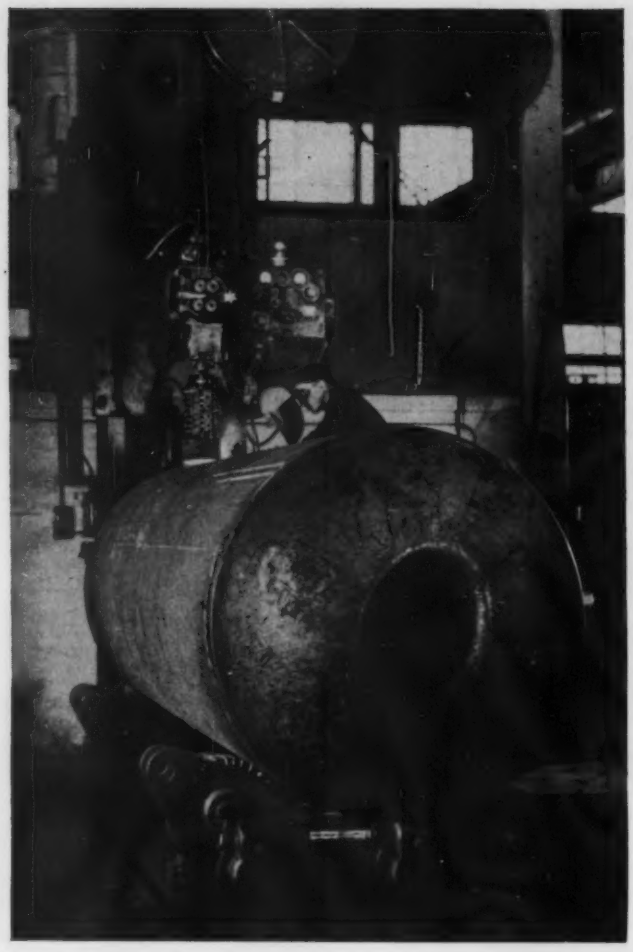

Fig. 9—Automatic welding of circumferential seam. Drum is rotated under the stationary welding head

Fig. 10—Grinding circumferential seam of drum

ing the test plate, and on both ends of grooves where no test plate is attached, two small bars forming a "V" are tack-welded to the shell so as to continue the weld properly to the end.

Each new layer of weld metal serves to normalize the grain structure of the previous layer. After each layer is deposited, the welded surface is cleaned with a rattler—a blunt-nosed tool operated by an air hammer—to remove slag and to allow inspection for defects. The laying-in of weld metal is continued above the surface of the shell and then the last layer is ground off flush with the surface, thereby removing any unrefined metal as well as providing a smooth surface for radiographic examination. The weld is then chipped out to sound metal on the inside of the shell and the groove thus formed is rewelded by hand. This weld is continued

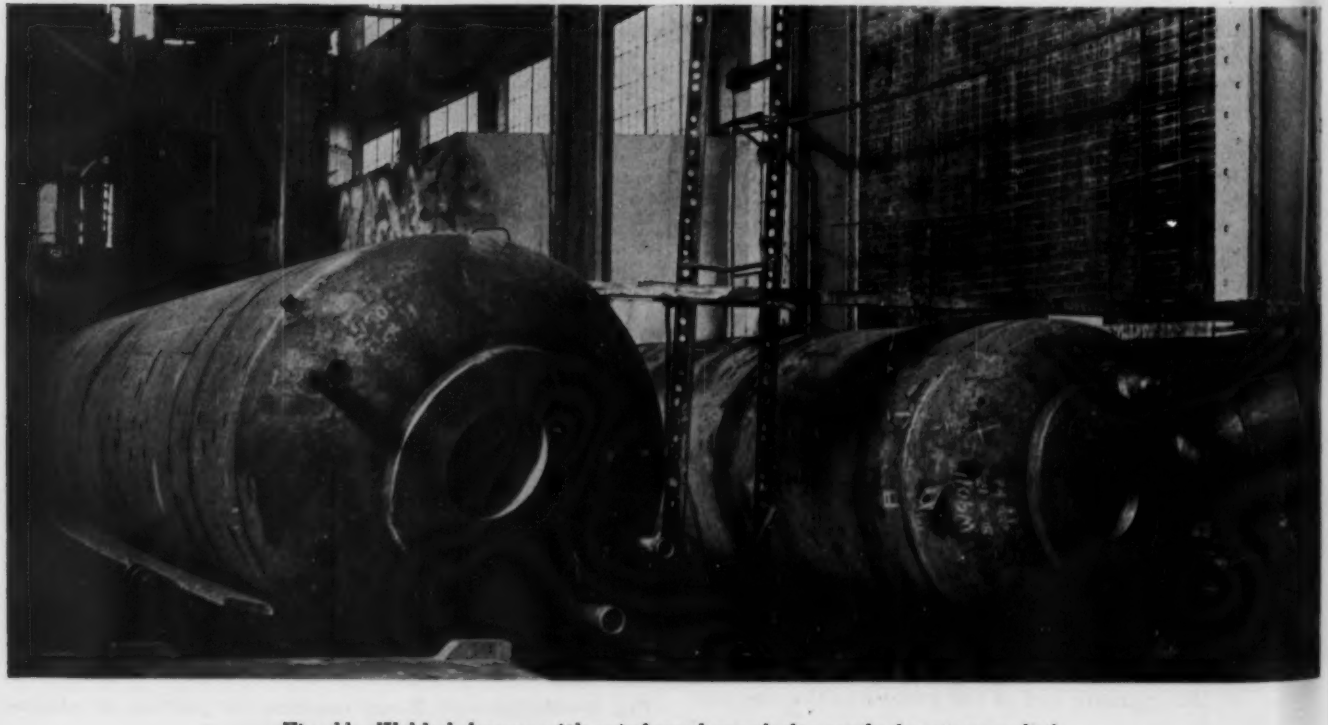

Fig. 11—Welded drums with reinforced manholes ready for stress-relief

above the inside surface and ground off flush as was done on the outside. The test plate is cut off and sent to the testing laboratory.

The shell is now ready for radiographic examination of the longitudinal seams. Three different types of machines are available for this work. The machine which is used depends on the thickness and length of the shell. Portable machines, mounted on four-wheel trucks and operating at 250,000 volts are used for smaller work. Heavier shells and drums are X-rayed by stationary 400,000-volt machines mounted at the side of tracks along which the drum can be moved on a car. Examination of very thick or long shells and drums is made with the 1,000,000-volt machine which is supported by an overhead pantograph with a universal crane mount so that the tube can be used in any position. This unit is housed in a special room with thick concrete walls. No persons are allowed in the room while X-raying is in progress. Power cannot be turned on until all doors of the room are closed. If any defects are disclosed by the X-ray photographs, the parts in question are chipped out, re-welded and given another examination.

Upon approval of the X-ray photographs, the shell is placed either in a lathe or in a horizontal boring mill where the ends are trued up and machined for welding on the heads. In the meantime, the heads have had the necessary attachments such as reinforcing pads, nozzles, etc., welded in place as the work can be handled more conveniently and welding can be in down-hand position.

After fitting and welding internal connections, the heads are fitted and tack-welded to the shell. The circumferential welds are made in the same manner and with the same type of groove as the longitudinal welds except that for the former the drum is rotated under a stationary electrode while for the latter the shell remains stationary and the arc moves along the seam. No test plates are required for the circumferential welds when the conditions of welding are the same as for the longitudinal welds.

Examination of the circumferential seams follows the same procedure as for the longitudinal seams, except that the drum is revolved in front of the X-ray tube.

Upon approval of the X-ray photographs, the drum is ready to have nozzle openings drilled or flame-cut. Nozzles and externals such as superheater supports, etc., are then welded and the drum is cleaned preparatory to stress-relieving.

The car-type furnaces used for relief of locked-up stresses caused by the welding operations are fired by oil and have automatic recording instruments for the control of temperature. The drums are loaded on drum chairs on the furnace car which is then rolled into the furnace. The end door is closed and the drums are heated to 1150 to 1200 F and held at that temperature for one hour minimum per inch of thickness. When this so-called "soaking" is completed, the drums are allowed to cool slowly in the furnace after which they are prepared for the hydrostatic test.

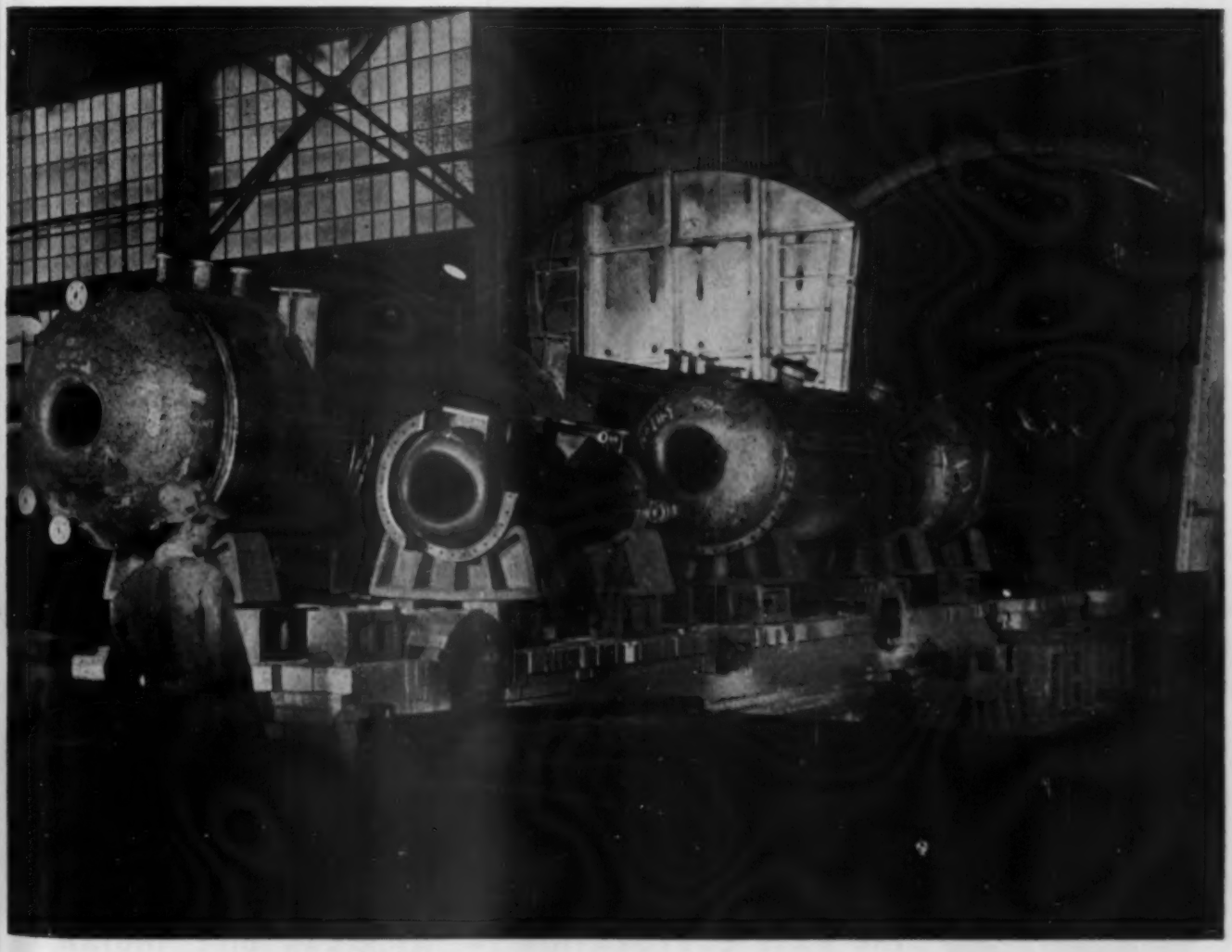

Fig. 12—Welded drums entering car-type furnace for stress-relieving

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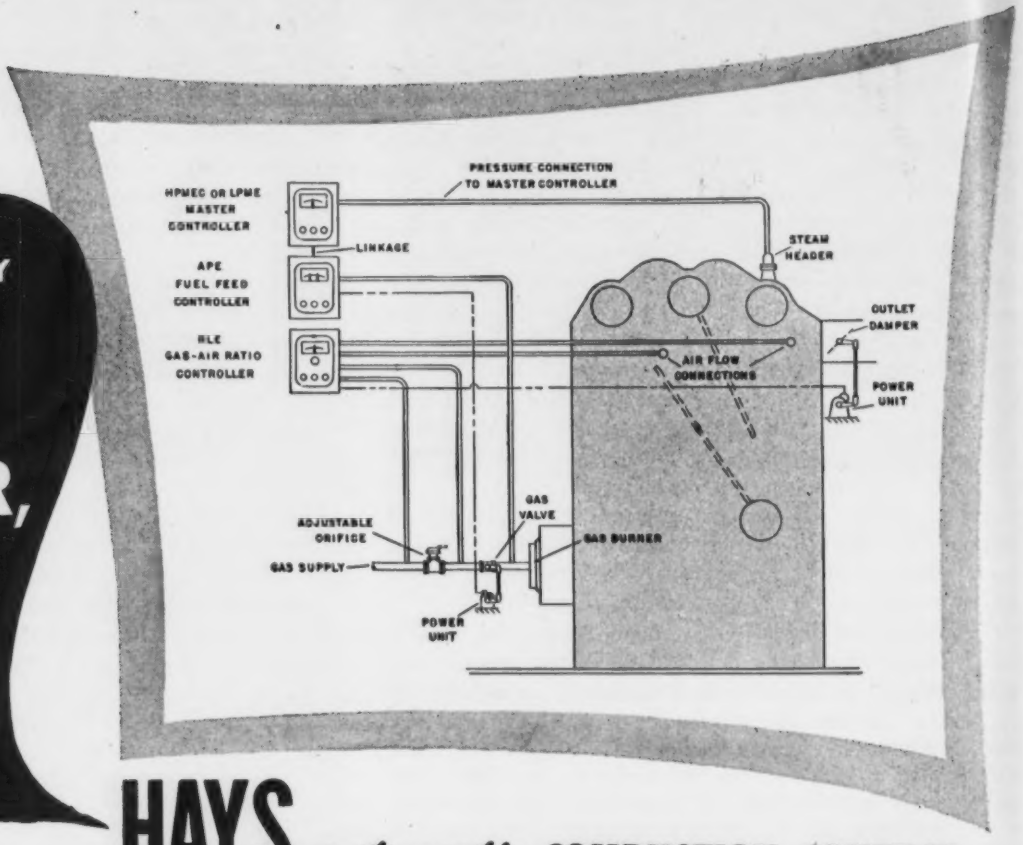

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- ***Master Steam Pressure Controller*** . . . . connected to the main steam header, it controls operation of other units, to maintain steam pressure constant.
- ***Fuel Feed Controller*** . . . is adjusted by the Master Controller for the rate of gas flow required for the steam to be generated. It controls the pressure of the gas at the burners by operation of a valve ir. the gas line.
- ***Gas-Air Ratio Controller*** . . . measures the flow of gas and proportions the air flow to the gas flow by operating the inlet damper. Gas flow is measured by taking the differential across an adjustable orifice in the gas line while the air flow is measured usually by taking the draft loss through the boiler.
- ***Furnace Draft Controller*** . . . (used only with forced draft burners) operates the boiler outlet damper, to maintain furnace draft constant at the predetermined value for which it has been adjusted.

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MID WEST POWER CONFERENCE

The following report covers high spots of a number of the papers presented on a wide range of power subjects, including power plant design, trends in the use of electric power, station performance, industrial power, atomic energy, gas turbines, feedwater treatment, fuels and fuel handling, and hydroelectric development. Space does not permit a review of other papers on strictly electrical subjects, diesel power, space heating and air conditioning. A new feature of the meeting was a general session dealing with the role of the engineer in civic affairs.

WITH a program timed to present needs in the field of power generation and application, the Ninth Midwest Power Conference got off to a good start at its opening session on April 3 at the Palmer House, Chicago, and continued through three days with an attendance of around 2500.

In a short pertinent address, **J. W. Cunningham** welcomed the guests and a response on behalf of the cooperating societies was made by **Dean T. R. Agg** of Iowa State College.

Two papers were presented at the opening session—one by **P. W. Swain,** Editor of *Power*, on "Atomic Energy" and one by **H. P. Seelye** of The Detroit Edison Company on "Future Requirements and Trends in the Use of Electric Power."

Mr. Swain dealt with the fundamentals of atomic energy, which have long been known, explaining these in simple language readily comprehended by the average individual. He pointed out that there are 92 natural elements ranging according to atomic weight from hydrogen (No. 1) to uranium (No. 92). Each atom has its nucleus about which electrons revolve in elliptical orbits. The nucleus contains only protons and neutrons, each with a mass of close to 1. The neutron is electrically inert while the proton has a charge of +1. The electron has a charge of −1 and a mass of 1/1850, which mass for practical purposes may be neglected. Hydrogen has one proton in the nucleus and one electron revolving around it, but no neutron. All the other elements have both neutrons and protons in their nuclei. For instance, helium, No. 2 element, has 2 protons, 2 neutrons and 2 electrons, and its atomic weight is 4.

Most elements have several forms, called "isotopes," the only difference between the isotopes being the number of neutrons, since both protons and electrons must equal the atomic number. For example, an isotope of hydrogen, called "heavy hydrogen," adds a neutron to the normal hydrogen nucleus, thus raising its atomic weight to 2; and this combines with oxygen to make "heavy water," having a molecular weight of 2 + 16 = 18.

Uranium, the heaviest natural element, has two important isotopes—"Uranium 238" and "Uranium 235" (or plutonium)—where the numbers indicate the approximate atomic weights as well as the exact number of protons plus neutrons in the nucleus. Since the protons in both cases must number 92, the neutrons are 146 and 143, respectively.

Atom splitting ("nuclear fission") means splitting the nucleus by impact from some other neutron. Generally, the neutron must move at high speed to split an atom but the chances of a neutron hitting a nucleus at such speed are small. In the case of uranium 235, however, it may be split by either a light or a heavy blow from a neutron and breaks up into two lighter nuclei with the release of a large amount of energy. A self-propagating chain action may be set up. There is a critical mass below which the atoms will not break up and above which they cannot be prevented from exploding.

Whether the chain be fast or slow, the fission of one pound of U 235 releases 39 billion Btu, equivalent to about 1400 tons of good coal and about one-tenth of one per cent of the uranium mass disappears.

Speaking of the possibilities of nuclear energy for power generation, Mr. Swain was of the opinion that because of the difficulties of pile operation and cost of protective measures, its use would be limited to large capacities of perhaps 100,000 kw and above. However, as there is no good reason to expect any reduction in the fixed charges involved or in operating supervision and labor, the saving in kilowatt-hour cost would likely not exceed 3 mils plus the cost of the uranium.

In conclusion, he urged that since there is no apparent ultimate protection in secrecy, in scarcity of uranium, in cost, in counter measures, or in storing up bombs, the solution to the present problem rests in proper international relations.

Future Requirements and Trends in the Use of Electric Power

Although much of Mr. Seelye's talk was based on studies made in the Detroit territory, it was susceptible to wider interpretation. Basically, he pointed out that, whereas it is important not to underestimate future loads, in order that sufficient capacity may be available when needed, on the other hand, too optimistic estimates may lead to excess investment to be carried by yearly income. Fixed charges on one major generating unit may well be of the order of one per cent of the total gross income of a system. Moreover, it is most difficult to predict the future population in any section.

Indications point to a continued increase in residential load, but the average load per customer will be affected by the trend toward smaller dwellings and the increased use of fluorescent lighting. Electric cooking is on the increase but such load comes on the system peak. Refrigeration load is likely to show only a moderate increase; water heating by electricity is a desirable load; but there is little prospect for home heating by electricity.

The wide use of fluorescent lighting on the commercial load will tend to offset increases in the number of customers in that field. Air conditioning as a summer load, off the seasonal peak is desirable.

Industrial consumption is related to power per worker. This in the Detroit area increased from about 4000 kwhr per yr in 1920 to about 15,000 kwhr in 1946. New developments in welding, in the heating of metals and in chemical processes may increase this further; but, on the other hand, industry is now pretty well electrified as to motor power and the trend toward shorter daily working hours may continue and tend to counteract a rapid growth in industrial load.

The pre-war (1938–1941) yearly load factor of the Detroit Edison System was around 47 per cent, and this stepped up to over 60 per cent during 1942–1944. It is expected to be lower than that in the coming years although appreciably above the pre-war figure.

Problems in Power Plant Design

Addressing the first luncheon session, **Alf Kolflat,** of Sargent & Lundy, discussed certain problems in power plant design, some brought about through war conditions and others through normal development.

The reduction in safety factor from 5 to 4 in boiler design he considered fully justified by the improved technique in boiler fabrication methods over the years since the higher figure was adopted.

On the other hand, there is a tendency to revert to pre-war piping standards.

It is too early, he believed, to judge how the wartime substitution of steel for copper in many power plant applications will stand up: but in many cases steel tubing in high-pressure feedwater heaters has already required replacement.

Because of the wartime steel situation attempts were made to use concrete in many places in power plant construction, but it was found to require too much lumber for forms, in addition to a considerable amount of steel for reinforcing. The difficulty in procuring materials still continues.

Plants constructed during the war, in general, did not cost any more than pre-war plants; but from now on it is reasonable to expect an increase of 20 to 30 per cent.

Steam conditions, Mr. Kolflat regarded as strictly an economic problem; that is, expected increase in economy versus initial cost. The incremental improvement in efficiency is less as the pressure is increased. He regarded 1200 to 1800 psi as generally the most economical range for large plants; and, all things considered, many medium-sized plants are about as efficient as large plants.

As to plant location, coal haulage of 200 to 250 miles is about as cheap as electric transmission from a plant located at the mines, and the tendency is to locate with regard to load centers.

He was of the opinion that it would be a long time before the gas turbine could compete successfully with steam for large plants; and doubted that atomic power, if and when it becomes available, will make any appreciable difference in the cost of power to the consumer. The answer to cheaper power lies in more economical distribution and improved load factor.

Other problems to be met are: changing fuel conditions; reduction in labor, particularly in emptying coal from cars, where the size of plant does not warrant installation of a car dumper; and less bulky and cheaper methods of dust collection.

Automatic Control

Two papers were presented at the Central Station Session—one on "Automatic Control of Steam Generation and Auxiliaries," by **P. S. Dickey,** chief engineer of the Bailey Meter Co., and the other on "Operating Experiences at the Marysville Power Plant of The Detroit Edison Co.," by **G. F. Campou.**

Mr. Dickey gave the following figures on the consumption and distribution of bituminous coal in this country during 1943:

BITUMINOUS COAL CONSUMPTION 1943 FOR UNITED STATES

Principal Consumers	Tons	Per Cent
Process		
1. Coke Ovens	102,918,000	17.3
2. Cement Mills	5,859,000	1.0
3. Others	12,842,000	2.2
Total	121,619,000	20.5
Steam Power and Heat		
4. Electric Power Utilities	76,477,000	12.8
5. Industrials	144,048,000	24.2
6. Railroads	130,278,000	21.9
7. Retail Dealers	122,764,000	20.6
Total	473,476,000	79.5
Grand Total	595,086,000	100.0

Stationary steam-generating plants shown in Groups 4 and 5 consumed approximately 210 million tons and it is estimated that there were more than 8000 coal-fired boilers operating with automatic control. These accounted for about 100 million tons of bituminous coal, or nearly half of the coal burned under stationary power boilers in 1943. Automatic control is used to an even greater extent with oil- and gas-fired boilers. Experience gained in producing and applying automatic control to a large number of steam plants built during the war should result in more standardized and more economical systems for small and medium-sized plants in the future.

	Type of Feedwater Regulator		
Boiler Capacity	Self-Operated Single-Element	Relay-Operated Single- or 2-Element	Relay-Operated 3-Element
1. Below 75,000 lb/hr	For steady loads (building heating or continuous processes)	For irregular loads (batch processes, hoist, rolling mills, etc.)	
2. 75,000–200,000 lb/hr	Use only in special cases	For all steady and fluctuating loads	For extreme load and water conditions and boiler with steaming economizers
3. Above 200,000 lb/hr		Use only on steady loads	For all types of loads

Note 1. Excess pressure ahead of feedwater regulator should be at least 50 psi.
Note 2. Excess pressure should be controlled by regulation of feed pump. Use excess pressure valves only when excess pressure varies more than plus or minus 30%
Note 3. Where drum level is unsteady due to solids concentration or other causes use next higher class feed regulator.

The speaker then discussed controls for various types of plants, such as base-load, peak-load, high-pressure and high-temperature, marine, etc., with solid, liquid and gaseous fuels and reviewed the methods ordinarily employed for determining and controlling the relation between fuel and combustion air. The above table provides a convenient means for selecting the most suitable type of feedwater regulator.

Experiences at Marysville

Mr. Campou's paper dealt particularly with the three later steam-generating units constituting the high-pressure extension of Marysville power house. These are each of 440,000 lb per hr rated output at 865 psi, 910 F and supply steam to a 75,000-kw turbine-generator. They are tangentially fired with pulverized coal, have vertically adjustable burners to control furnace outlet gas temperature, and are designed for a conservative furnace heat release of 20,000 Btu per cu ft. Although soot blowers were installed for the furnace walls, these have not been used for two years.

Only slight deposits have been encountered at the cold end of the regenerative air preheaters and these are removed by blowing twice a week. The mean air temperature is maintained above the dew point of the gas and this has obviated corrosion of the elements.

The flue-dust collectors, of the electrostatic type, have been generally satisfactory, although accumulations on the plates have caused occasional short-circuiting. Rapping devices are therefore being considered for removal of deposits. The fly ash collected amounts to about 40 tons per 24 hr.

On the first boiler the flue-dust collector was placed beyond the induced-draft fan, and after six months' operation this resulted in erosion of the scroll. This was overcome by installing annular deflectors. On the next two boilers the flue-dust collectors were placed ahead of the fans and erosion has been obviated.

At first the bowl mills were not up to full capacity of 12 tons per hour each. This was rectified by alterations in the mills so as to introduce the coal through a center feed pipe and a portion of the primary air with the coal feed to prevent hanging up in the feed pipe. Also, the bottom of the bowl was made flat. These changes increased the mill output from 11 to 13 tons per hour, with no increase in power consumption.

Some changes have been made in the ash-transporting system from the fly-ash collectors to minimize wear on the conveying pipes, and it was found that where wear did occur at elbows, cement patches were superior to welded steel plates.

A fully automatic combustion control system of the air-operated type is employed and here some changes have been made to promote simplicity.

An automatic unloader has been placed on the turbine, and some changes were made in the air passages of the generator cooling system. As a result of the latter, the new fields are showing considerably lower temperature.

Feedwater Treatment

In contrast to the usual chemical dissertations on feedwater treatment, a paper by **Leo F. Collins,** chemical engineer of The Detroit Edison Company, dealt with the engineering aspects, including economic considerations, preliminary studies, treating capacity, operating guides and instruction of operators.

In the higher ranges of steam pressure, water conditioning partakes more or less of experimentation, and engineers are usually tolerant when troubles occur; but when troubles occur at pressures for which the technology of water conditioning is virtually complete, such troubles usually manifest voids in the science of water chemistry. However, recurrent troubles are more often the result of misapplication of treatment than of such voids. Efforts to economize and inadequate instruction of those responsible for operation of treating equipment are most frequently the basic cause of recurrent troubles.

Too often preliminary studies are either omitted or superficially conducted; inadequate treating capacity is provided; too few operating guides are supplied; and treating equipment is "stuffed" into the plant.

Where more or less elaborate treating schemes are involved, one of two policies is usually pursued. The first holds that if one treating unit becomes inoperative, there should still be adequate capacity to meet maximum boiler demand; the second holds that the treating system should be capable of operating under overload to meet peak demands. The latter is the more usual. When boilers are to be operated at peak steaming rates, provision of standby treating equipment is, in Mr. Collin's opinion, advisable for two reasons: First, under such conditions the boilers demand water of optimum chemical quality; and second, when treating equipment is operated at overloads, the water invariably is less precisely conditioned.

As to operating guides, pending development of reliable meters for measuring chemical concentrations, the author recommended, as substitutes, indicating and recording instruments that reveal physical changes, sampling and routine chemical testing apparatus, and an adequate system of keeping records. Each of these he discussed at some length. Moreover, as a competent method of treatment requires intelligent operators, it follows that the equipment should be located in a place where intelligent men will work.

The author observed that to become a competent feedwater operator, considerably more instruction is necessary than that required to manipulate routine tests. Experience indicates that young operators are usually easier to train than more experienced operating men; but technical counsel should have as its purpose not only initial instruction of operators, but also to keep them instructed.

The second paper of the Feedwater Session, with **M. E. Fitze** and **F. H. Long** as authors, dealt with experiences with the 1300-psi, 900-F installation at the Commerce Street Station of the Wisconsin Electric Company, which employs high makeup (up to 60 per cent) and where excessive turbine clogging with water-soluble and insoluble deposits was encountered.

This 35,000-kw tandem-compound turbine has four stages of extraction to provide feedwater at 390 F. Also, the fourth stage is bled to provide steam to the high-pressure heating system and to a 150-psi line that serves as a booster to the low-pressure system in the center of the downtown heating area. It will be recalled that this station is the principal source of steam for the Company's central heating system on the west side of the Milwaukee River. The fourth extraction point also provides steam for the turbine-driven boiler feed pumps, the exhaust normally being routed to the low-pressure heating system.

The insoluble silica deposits have been reduced about 90 per cent by internal boiler treatment with magnesium oxide in the absence of phosphate.

Simultaneous internal treatment with barium chlo-

ride is also employed for sulphate reduction to lessen superheater and turbine deposits.

Carbonaceous zeolite softeners allow operation with extremely low calcium in the makeup water (0.25 ppm) for assurance against boiler scale formation.

A year's experience with internal treatment of magnesium oxide for silica removal in the absence of phosphate (which at 1300 psi interferes with silica removal by magnesia) has shown no detrimental effects other than a proportionate increase in boiler sludge. Insoluble silica deposits in the turbine have been proportionately reduced.

Approximately 8½ months' internal treatment with barium chloride for reduction of superheater clogging by sulphate has shown no detrimental effects other than the proportionate increase in sludge, and the formation of feedline deposits at the point of injection.

Organic contamination of the boiler water through decomposition of carbonaceous zeolite at 1300 psi resulted in excessive turbine clogging by water-soluble deposits. However, such deposits were easily removed by water washing.

Industrial Power Plants

This session included three papers, namely "Modernization of Small Power Plants," by **C. M. Garland,** consulting engineer; "Smoke Abatement in Small Power Plants" by **Carroll F. Hardy,** chief engineer of Appalachian Coals, Inc.; and "Extraction Turbines for Industrial Power" by **L. E. Newman** of General Electric Company.

Defining small power plants for the purpose of his paper as those from a few kilowatts up to 20,000 kw, Mr. Garland cited the gradual supplanting of the steam engine by the steam turbine and the incorporation of many of the technological improvements found in large stations, such as employment of higher steam pressures and temperatures, improved furnaces, boilers and stokers, increased use of heat-recovery equipment, combustion control, instruments, etc. As a rule, he contended, the engineering problems of the smaller industrial power plant are far more numerous and often more difficult for the designer than those of a central station, for in the latter case more of the major problems concern design of the equipment rather than that of the plant. One of the more common problems with which industrial power plants have to contend is that of extremely variable load; another, especially in small plants, is that of keeping down labor costs, which the speaker believed would favor the diesel engine for those plants where process steam is not required and where there is no large heating demand.

Mr. Hardy presented data from a survey, made by his organization, of 2200 plants in twelve cities or their vicinities. Of these, slightly over 8 per cent were in first-class operating condition and fired correctly; and 15 per cent, while showing minor defects, were well operated. One-third of those properly operated were hand-fired and the balance mechanically fired. However, about two-thirds of all the plants surveyed had operational difficulties, with incorrect firing heading the list. This included such things as unnecessary stirring of the fire, overloading the furnace, trying to force a cold boiler, poor maintenance, and permitting excessive accumulations of soot and fly ash in the gas passages and breeching. In both stoker- and hand-fired plants, about 5 per cent had leaks in the breechings and stacks, and many of the breechings had unnecessary turns and restrictions. Poor draft conditions were prevalent. The presence of smoke in many cases he attributed to the fact that the fireman usually cannot see the top of stack and has no smoke indicators; or he may have other duties in addition to firing the boiler. Where instruments were installed they were often not maintained in proper condition and in some cases were disconnected. Seventy per cent of the plants surveyed were not well maintained.

In discussing the operation of various types of firing equipment, from the standpoint of avoidance of smoke, Mr. Hardy recalled that many plants do not put in large enough stokers to meet growing load. He also cited the shortcomings of "on-and-off" control, and mentioned steam jets for the introduction of over-fire air as an effective means of cutting down smoke.

The influence of process steam on the purchase of industrial turbines over the last 15 yr was cited by Mr. Newman who presented the following tabulation:

PER CENT OF TOTAL NUMBER OF UNITS

	1931–1935	1936–1940	1941–1945
Straight condensing	16	15	8
Condensing extraction*	34	36	44
Straight noncondensing	38	32	36
Noncondensing extraction*	12	17	12
Total	100	100	100

* These include units of the single-automatic and double-automatic extraction types.

While these figures are based on the sales of one manufacturer, they are believed to be representative of the industry. It will be noted that only a small proportion of the units are straight condensing and many of these are operated in conjunction with noncondensing or extraction turbines. The trend is toward units of the condensing-extraction type.

With reference to advances in steam conditions, Mr. Newman pointed out that the average industrial turbine purchased in 1930 was designed for 240 psi 500 F, but this had climbed to a 1945 average of 475 psi, 680 F, and indications point to a further upward trend.

Wide differences in end-products and manufacturing processes have been responsible for many variations in turbine design. In the range of ratings of 500 to 7500 kw there are now 14 standard ratings and 8 basic turbine types, making a total of 112 different designs, caused simply by difference in rating and type, which represent the simplest variables. Far greater are the variations caused by initial pressures, exhaust pressures, extraction pressures and extraction steam flows. There are also various frequencies and voltages encountered with different processes, as well as space requirements to be met. Taken together, there are many thousand variations to which industrial turbines are subjected. The difficulties of standardization are therefore apparent.

Said Mr. Newman, "The small power plant hurls a challenge at us to extend to it some of the benefits that might result from standardization. So far, the acute need of fitting the turbine to the job has outweighed other considerations to the point that little thought has been given to standardization of these highly specialized types of industrial machines. Instead, the manufacturer has developed designs of such remarkable

flexibility that the most complex turbines are assembled from standard parts. Even so, there are ample rewards ahead for those bold enough to pursue standardization of these small power plants."

Under-Bunker Conveyors

A paper on "Under-Bunker Conveyors," by **A. J. Stock** of Stock Engineering Company, discussed and illustrated various layouts and applications of coal conveyors installed between a bunker and the point of use of the coal. The five basic reasons for employment of such conveyors he enumerated as follows:

1. To feed coal to stokers or pulverizers which are so located in relation to the bunker outlets that coal cannot be fed to them by gravity.
2. To reclaim coal from dead spots that exist between the principal bunker outlets.
3. To reduce the frequency of coal-loading operations.
4. To quickly and easily empty any section of the bunker for repairs or for the prevention of bunker fires.
5. To make possible operation of the boiler plant for the maximum number of hours in the event of a breakdown of equipment that elevates and conveys coal to the bunker.

While under-bunker conveyors are usually designed to suit the individual requirements of a plant, there are several more or less typical designs which fit the requirements of many plants. These were illustrated, as were also several bad arrangements that are to be avoided. Among the points mentioned as constituting a well-designed conveyor were that the conveyor housing, chutes and inlets should be at least 15 or 16 in. square; the thickness of plate used in the housing should be at least $^1/_4$ in., and preferably $^3/_8$ in. to insure good life; the housing should be dust-tight; ample hinged and gasketed access doors should be provided to notify the operator when the coal supply is exhausted at the bunker outlet in use; and the conveyor should be designed for point-to-point transportation of the coal. Also, it is most important that the chutes and downspouts be so designed as to reduce to a minimum the possibility of coal sticking; and feed connections should be such that any water draining out of the bunker will not collect in the conveyor. Finally, the feeding capacity should be only slightly more than the burning capacity of the boiler or boilers, as too high a conveyor capacity means too many starts and stops.

Gas Turbines Discussed

In line with the increased attention being given to the design and application of gas turbines, the program included four papers on this subject. The first entitled, "Where the Gas Turbine Stands Today" by **L. N. Rowley** and **B. G. A. Skrotski,** both of *Power*, outlined and compared the characteristics of gas power cycles and summarized the efforts made to date to realize cycle possibilities in commercial machines. Conclusions of the authors were that the gas turbine has been established as thermodynamically practical and that the mechanical problems associated with high-efficiency, high-temperature design can probably be solved on a commercial basis. If successful methods of burning solid fuels directly in the gas circuit can be developed, the potential field of application will be greatly widened.

Seven power-generation installations now on order from a foreign manufacturer were listed for installation chiefly in Europe and South America. These range in capacity from 1200 to 10,000 kw and will burn oil or natural gas. The highest recorded open-cycle efficiency, of 29.5 per cent, was attained with a unit designed for marine service. An American design for 1200 F maximum temperature shows 20 per cent efficiency with regeneration and another unit, now under development, is expected to reach 23 per cent without regeneration when operating at 1350 F.

The second paper on this subject, entitled "Linear Relationship in Gas Turbines," by **Dr. J. T. Rettaliata,** showed how the several important variables in gas-turbine cycles can be made to bear linear relationships with each other. These were illustrated by numerous charts and curves and included enthalpy changes for different pressure ratios and inlet temperatures for the turbine, compressor and combustion chamber, as well as such linear functions for fuel consumption, power and efficiency. Increase in thermal efficiency by employment of regeneration and by intercooling was also discussed.

The third paper on the gas turbine, by **J. R. Carlson,** of Westinghouse Electric Corporation, reviewed some of the war work in connection with jet propulsion that had given impetus to the present development work in this country on gas turbines for stationary, marine and railway use.

As to temperatures involved, he stated that steam turbine blades are made of 13 per cent chrome-iron alloy and are fabricated by heating to 1900 F at which temperature the metal becomes soft and plastic so that they can be shaped by a drop-hammer. If these blades are reheated to 1350 F, a temperature that is looked upon as desirable for gas-turbine work, they would become plastic and under sustained stress would lose their form. Obviously, the use of metal common to steam-turbine work will not suit the gas turbine and other alloys having high strength at elevated temperature must be used. Such alloys, in general, contain large percentages of chromium, nickel and cobalt to which have been added "vitamins" such as tungsten, titanium, molybdenum, columbium and vanadium. Such materials cost from 4 to 5 times as much as those employed for steam-turbine blading.

Considering the possibilities of the gas turbine becoming a competitor of the steam plant for central station service, Mr. Carlson recalled that the most efficient steam plants now have thermal efficiencies of 32 to 34 per cent and many exceed 30 per cent. To match this, one must have something more than the simple open-cycle gas turbine, which means extensive heat-reclaiming apparatus such as a regenerator and intercooling combined with a stage of reheat on the turbine. These will be costly and occupy considerable space. The two methods suggested for reducing size and weight of expensive materials are: (1) operation of the turbine and compressor at very high speeds; and (2) initially pressure-charging a closed system. The latter is now receiving much attention in Europe.

The future of the gas turbine as summarized by Mr. Carlson, with reference to the probable importance of

its applications was: first, in the aircraft industry, for both jet propulsion and gas-turbine propeller drive; second, in railway service; third, a possibility in some marine applications particularly with reversible pitch propellers; and fourth, stationary plants in which the central station offers the smallest field for use, with the possible exception of peak-load applications where the more elaborate and expensive, most efficient, types would not be warranted.

John I. Yellott, Director of Research for the Locomotive Development Committee of Bituminous Coal Research, reported further progress on the experimental work now being conducted at Johns Hopkins University, Battelle Memorial Institute and the Institute of Gas Technology, Chicago, on "Coal as Fuel for the Gas Turbine." This work was previously described in a paper by Mr. Yellott and A. D. Singh before the Annual Meeting of the A.S.M.E. last November. As will be recalled, it involves coal pulverization by passing crushed coal through an expanding nozzle under 70 to 100 lb air pressure, the burning under pressure at high combustion rates (500,000 to 1,000,000 Btu per cu ft per hr) in a vortex combustor and extraction of ash from the gas by means of small cyclones in multiple, before entering the turbine.

St. Lawrence Power

The present status of proposed hydroelectric development of the St. Lawrence River was reviewed by **C. H. Giroux,** special assistant to the Chief of Engineers, U. S. Army.

Reviewing the background of this proposed development, he recalled that as early as 1909 an International Joint Committee was formed, as a result of a treaty with Canada, to have jurisdiction over matters pertaining to boundary waters between the two countries. Nothing was done, however, until 1919 when Congress requested a study of the St. Lawrence River between Lake Ontario and Montreal. The report, made in 1921, recommended a combined navigation and power project involving a 25-ft deep channel and development of 1,850,000 hp in a power house at Long Sault Island.

A Joint Board of Engineers was appointed in 1926 to further study the recommendations, but the Canadian representatives preferred a single-stage plan and the Americans a two-stage development. Numerous subsequent reports were made, finally culminating in the agreement of March 19, 1941, which provided for a complete project involving both power and navigation, with an equal division of power from the International Section, and division of the cost, the power on the Canadian side to be marketed by the Hydroelectric Power Commission of Ontario and that on the American side by the New York State Power Authority. The agreement was incorporated in a bill which has not yet passed Congress.

In 1940 the President, by executive order, created the St. Lawrence Advisory Committee consisting of representatives of the Federal Power Commission, the U. S. Corps of Engineers and the New York State Power Authority, to make preliminary surveys and prepare plans and specifications.

The resulting plan calls for three dams, a 27-ft navigation channel, with several 80 % 800 ft locks and a single-stage power development at Barnhart Island. The power house, 3585 ft long by 180 ft wide (bisected on the International Boundary) would house 36 generating units, each of 61,100 hp at a normal head of 81 ft and most efficient gate opening, or 67,100 hp at full gate and the same head. Both 60-cycle and 25-cycle generation is contemplated. A total firm capacity of 1,150,000 kw is anticipated with an annual energy output of 10,110,000,000 kwhr. Two additional units of 7500 kva would be provided for station service.

Civic Responsibilities of the Engineer

At a general session devoted to the topic: "Your Nation's Future—an Engineering Problem," six prominent engineers and educators discussed the problem of how the engineer can become an effective force in community and public life.

Leading the discussion, **Dean A. A. Potter,** of Purdue University, observed that too few in the engineering profession have shown any interest in government and have overlooked the fact that the engineer as an individual is an integral part of the social structure. Our industrial progress and high standards of living, he said, have usually been attributed to our great natural resources, but these alone are of little value in raising the standards of living of a nation unless the people have character, vision, initiative and creative ability to utilize them. Our industrial progress in the past, while partly due to national resources, is mainly attributable to the fact that our people have been stimulated to develop the will to have and to work. At present too many people place security above opportunity (which was not true of our ancestors who laid the foundation for a great nation) and regard government as Santa Claus.

However, creative genius does not flourish under governmental regulation and control. Government must be the agent and not the master of the people. Engineers must resist inroads on the Federal Treasury and insist that proposed projects have merit.

Dr. Roy V. Wright, past-president of the A.S.M.E., recalled that although science and engineering have conferred vast benefits upon civilization, and have raised standards of living to a level unthinkable a century ago, the engineer is too indifferent to the social and economic problems for which he is partially responsible. Democracies have failed because of indifference of their citizens. The speaker then reviewed the work that is now going on within the A.S.M.E. to stimulate greater interest in responsible citizenship. In this, special attention is being given to the younger engineers.

Other speakers on the panel were **Melvin J. Evans** of Chicago, **L. J. Fletcher,** director of training and community relations, for the Caterpillar Tractor Co., **Samuel R. Harrell** of the Acme Evans Co. and **F. A. Faville** of Faville-LeVally Corp.

The "All Engineers" Dinner on Thursday evening was devoted to military topics. With David Levinger, vice president of the Western Electric Co. as Toastmaster, the speakers included Rear Admiral John T. Manning who talked on "Engineering as a National Safeguard"; Lt. General Raymond A. Wheeler, Chief of Engineers, who outlined the functions of the Corps of Engineers in war and peace; and Brig. General George Armstrong who told of the work of the Army Industrial College.

Power Subjects at the A.S.M.E. Spring Meeting

From the power engineer's standpoint a feature of the Spring Meeting of the A.S.M.E. at Chattanooga, April 1-3, was a panel discussion on "Corrosion in Power Plant Operation." Participating in the panel was D. C. Carmichael, of E. I. du Pont de Nemours Co.; Dr. M. G. Fontana, professor of metallurgy at Ohio State University; W. L. Webb of American Gas & Electric Service Corp.; Ray Benjamin of the Georgia Power Co.; John Van Brunt, vice president of Combustion Engineering Co.; and T. B. Allardice, also of Combustion Engineering Company, who substituted for J. A. Reich of Virginia Electric Power Co. J. A. Keeth, of the Kansas City Power & Light Co. presided.

Dr. Fontana opened the discussion with an explanation of the three basic classes of corrosion, namely, metals in contact with nonmetals, electro-chemical and wet and dry corrosion. Uniform or general attack can generally be predicted, and in the case of galvanic action, where two dissimilar metals are involved, one will always be protected and the other suffer. By means of slides he illustrated crevice type corrosion, dezincification, stress corrosion (caustic embrittlement and corrosion fatigue), intergranular attack on which the metal becomes brittle, pitting and erosion-corrosion resulting from high-velocity impingement.

In the general discussion that followed the subject of chemical cleaning of boilers came in for much attention. Mr. Webb recalled one case where evidence of attack on tube ends was noted after four cleanings. Here stress in the vicinity of the groove may have been a factor. A different type of corrosion (pitting) occurred beyond the bell in the tube ends, and some honeycombing was apparent on the interior surface of the drum and the nuts holding drum internals. While it was conceded that chemical cleaning is here to stay, it is most important that the temperature be held below the point where the inhibitor, which slows down hydrogen evolution, tends to break down (generally at about 160 F); also all parts of the boiler should be heated up uniformly.

Furnace Wall-Tube Corrosion

A second topic that came up for discussion was furnace-tube wall corrosion. This which has occurred almost entirely in wet-bottom furnaces and was attributed to the presence of alkaline sulphides in the ash, not to heating or erosion. Contributing factors are overloading, furnace conditions and burner design and a reducing atmosphere along the furnace walls, although the last mentioned is not alone responsible. It was shown to have occurred in boilers involving not only tangential firing but also inter-tube firing, vertical and horizontal firing. Protective coatings of the tubes in this region, after six months' service have shown promise of avoiding such attack, although a longer period will be necessary to make certain of their effectiveness.

Mr. Carmichael cited a case of trouble with the corrosion of chrome-steel turbine blades in an industrial plant where the machine was not operated continuously. The trouble was rectified by substituting monel blading.

A case was cited by Mr. Allardice of extensive corrosion in regnerative-type air heaters where the plates became brittle and the bundles broke apart, although not subjected to stress. Investigation revealed that water had been leaking into the heater.

Some difference of opinion was evident as to the advisability of water lancing, although the consensus was that this must be done carefully, and in cases where air lancing is not effective a small amount of water with the air may be safely employed.

Mr. Van Brunt then showed slides of several types of tube failure and explained how to determine the cause from the appearance of the tube.*

At the second power session of the Meeting, C. L. Huey of Babcock & Wilcox presented a paper on "Modern Steam Generators." After reviewing the fabrication of such units he stated that one of the present design problems is to meet new requirements without unduly increasing costs. Superheat temperatures of 1050 F for high pressures and up to 1450 F for low pressures are now possible by employing combinations of various alloys for tubes. He then outlined three methods of superheat control, namely, use of bypass dampers, a mud-drum attemporator, and spray-type desuperheaters, or attemporators, placed between the primary and secondary superheater sections. Whereas the older boilers were hung, with all expansion taking place downward, and the furnace walls independently supported, in present-day designs the boiler and walls are integral and are either hung or supported from the bottom.

Conceding that slagging of furnace walls is inevitable, Mr. Huey stated that intermittent formation and removal of slag is undesirable, as it is likely to cause temperature stresses and thermal shock of the tubes. In this connection he stated that full-studded tubes will provide a uniform condition of the covered tubes; or where continuously clean tube surface is required, tangent tube construction is recommended. This latter statement was questioned from the floor and the speaker qualified it by saying that frequent use of soot blowers might be necessary.

What promised to be another most interesting paper, scheduled for the Power Session, namely: "Power at Oak Ridge" by L. Skog, was withdrawn because of restrictions imposed by the War Department.

* See his article in COMBUSTION, July, 1945.

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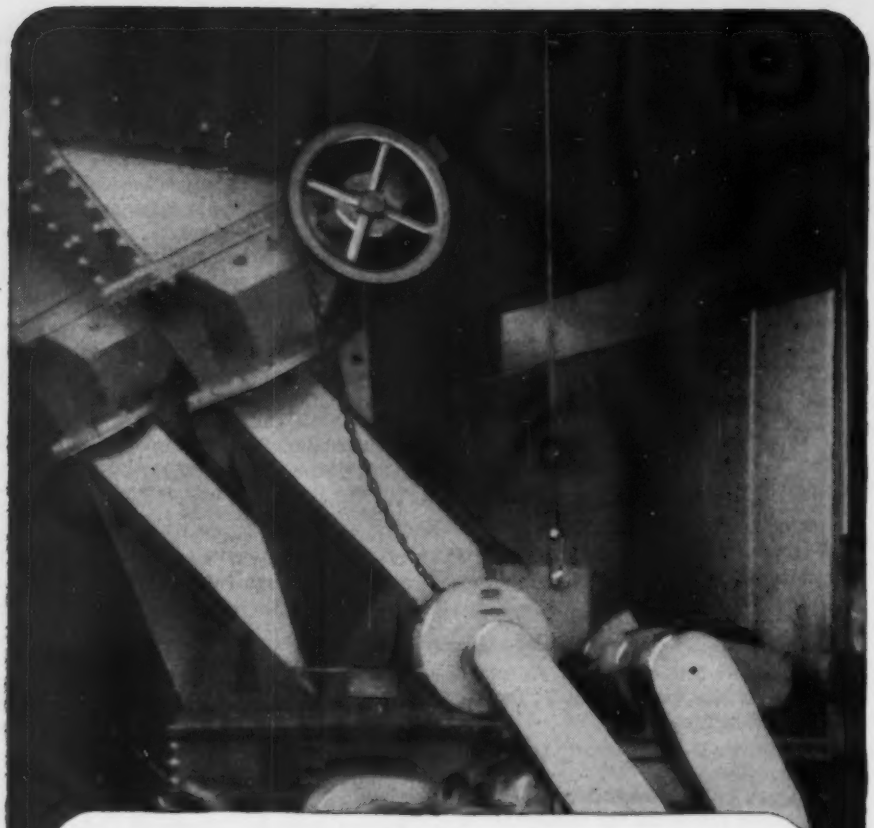

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A 3600-rpm turbine-generator for a maximum rated output of 100,000 kw at 1250 psi and 1000 F total steam temperature is now being built by the General Electric Company for the Essex Station of the Public Service Electric and Gas Company of New Jersey. It is scheduled for delivery early in 1947.

The machine, which will be of the tandem-compound, double-flow type, will have nineteen high-pressure stages and five stages in the double-flow low-pressure end. The last-stage wheel will have 23-in. buckets of variable-angle, double-warped airfoil section, and the maximum tip speed of the buckets will be 1390 ft per sec. The turbine will operate condensing and exhaust at 1 1/2 in. Hg. Eight extraction points are to be provided. It will occupy a space 77 ft long and 17 ft wide.

The generator, largest 3600-rpm machine ever constructed, will be rated at 95,000 kw at 85 per cent power factor and will be hydrogen-cooled by means of four vertical cooler sections mounted in the corners of the generator.

A.S.T.M. Committee's Report on Gaseous Fuels

At its recent meeting in Pittsburgh the A.S.T.M. Committee on Gaseous Fuels reported on a new tentative method for testing the calorific value of gaseous fuels by means of the water-flow calorimeter. This method is restricted to gaseous fuels having total calorific values in the range from 300 to 3000 Btu per standard cubic foot.

The Subcommittee on Determination of Specific Gravity and Density of Gaseous Fuels discussed studies that have been made at the National Bureau of Standards on eleven instruments for the determination, indication or recording of the specific gravity of gases. It was decided to set up a tolerance for specific gravity determinations which would be within the ability of the instruments tested. A complete report will later be published by the Bureau of Standards.

The Subcommittee on Determination of Water Vapor of Gaseous Fuels reported that it is studying a method which employs a chemical film, such as phosphoric acid, so placed as to cause two elements of an electrode to change the film's electrical conductivity with changes in moisture content of the gas surrounding the electrode.

Decrease in Electrical Output Reported

Electricity produced for public use last February, according to the Federal Power Commission, showed a decrease of 10 per cent from that of February 1945, and the combined production by utilities and industrial establishments during the same months showed a decrease of 11.7 per cent. The total output of electricity for public use for the twelve-month period ending February 28, 1946, was 218,753,617,000

kwhr, a decrease of 4.1 per cent below the corresponding period ending with February 1945. The capacity of utility generating plants in the United States as of February 28, 1946, was 50,120,183 kw and the industrial plant generating capacity reported was 12,757,164 kw.

A.S.H. & V.E. to Meet in Canada

The Semi-Annual Meeting of the American Society of Heating & Ventilating Engineers, scheduled for June 10–12, will open at the Mount Royal Hotel, Montreal, and continue on the cruise ship *Quebec* up the St. Lawrence with stops at Quebec, Murray Bay and Tadoussac. There will be three business and technical sessions. Canadian members will act as hosts.

In order to provide more adequate research facilities for serving the entire heating, ventilating and air-conditioning field, the Society has recently purchased property on Euclid Avenue, Cleveland, which will serve as a research laboratory. This represents another forward step in the Society's research program which has been actively carried on over the past 27 years.

Personals

David W. R. Morgan, manager of the Steam Division of the Westinghouse Electric Corp., has been appointed general manager of the entire South Philadelphia Works of that Company.

Raymond A. Durand, formerly assistant sales manager of Edward Valves, Inc., has been advanced to the position of sales manager of the company.

P. H. Lair has been made manager of the New York Sales Office of The Dampney Company of America.

Glenn C. Barnaby has been appointed San Francisco district representative of The Terry Steam Turbine Company.

Thomas B. Allardice, formerly of American Gas & Electric Service Corporation and recently returned from Italy, has joined Combustion Engineering Company, Inc. While in Italy he served with the Allied Commission as consultant on coal and power. Mr. Allardice will act as consultant in the application of C-E steam-generating units to the utility industry.

Obituary

James Williams, shop superintendent of The Terry Steam Turbine Co., died suddenly on March 18. Born in Manchester, England, Mr. William's early experience was with Galloways and the British Westinghouse Co. He then came to the United States and was first employed by the Westinghouse Company at Pittsburgh during which time he spent over a year in Japan. He joined The Terry Steam Turbine Co. in 1911, shortly thereafter being made shop superintendent and held this position at the time of his death. He was a member of the A.S.M.E. and the Hartford Engineers Club.

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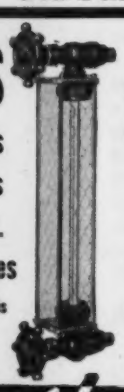

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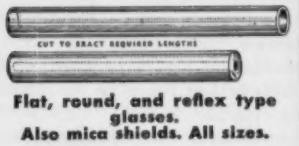

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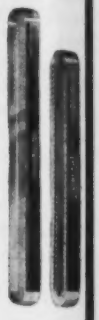

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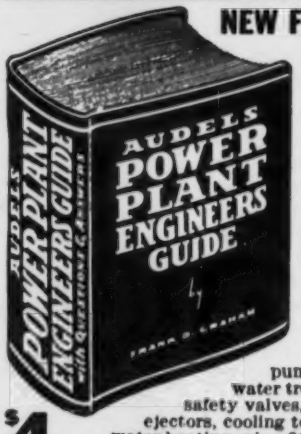

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NEW CATALOGS AND BULLETINS

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Magnetic Adjustable-Speed Drive

Electric Machinery Mfg. Company has published a 16-page booklet (No. 183) in which is covered its E-M Magnetic, Adjustable-Speed Drive for boiler draft fans, centrifugal pumps, blowers and compressors, and other loads where torque required decreases with reduction of speed. Principles of operation, performance characteristics, and applications are described and illustrated.

Rotameters

Fischer & Porter Company has issued a new 12-page catalog section (43-E) dealing with its line of armored rotameters for measuring and controlling flow rates at high pressures and temperatures. Standard armored indicating meters are described and also recording or recording-controlling or totalizing armored meters with readings at the meter or at a remote location. Illustrations include many designs to accommodate pressures as high as 10,000 psi and temperatures up to 750 F.

Stainless Steel

A 100-page pocket-size handbook presenting practical information on 26 types of stainless steels has just been published by Allegheny Ludlum Steel Corporation. It contains a 44-column finder chart giving analyses, properties, hot working temperatures and heat treatment of the different types and a general discussion of types and properties. This is followed by a table of corrosion resistance of four leading types of stainless to 230 chemicals and common materials. Fabrication methods and procedures occupy 40 pages while a description of stainless steel products comprises a 20-page section. Final pages contain general tables and reference material.

Single-Stage Pumps

Ingersoll-Rand Company has published a new 20-page catalog (Bulletin 7057) covering the design, construction and engineering details of its Cameron Single-Stage general pumps. These single-stage units are designed for capacities to 25,000 gpm, against heads up to 300 ft. They are available in several combinations of metals for a wide variety of liquids and industrial requirements. Considerable space is devoted to performance and dimension tabulation and the numerous illustrations include installation, cross-section and interior views.

Spray Nozzles

Yarnall-Waring Company has issued a 16-page bulletin (N-616) which describes its various types of spray nozzles for water cooling, air conditioning and for general industrial uses. This bulletin is profusely illustrated and includes capacity charts and dimension tables.

Steam Turbine Lubrication

Gulf Oil Corporation has just issued a 20-page booklet entitled "Gulfcrest Oil for Steam Turbine Lubrication." This booklet is handsomely illustrated and, in describing the operating characteristics and advantages of Gulfcrest Oil, it explains how air is actually beneficial to this product under service conditions in that it permits oxidation to proceed just far enough to produce additional oiliness; also, how the Alchler Process of refining makes this lubricant highly responsive to oxidation and corrosion inhibitors.

Solenoid Valve

Allied Control Valve Company has issued a bulletin (461) which illustrates and describes its V5-200 Solenoid Valve for use with CO_2, air, water, hydraulic fluids and other media.

Safety and Relief Valve

Safety and relief valves to match the improved designs of the latest power and process equipment are announced in a catalog, No. 45, just issued by the Farris Engineering Company. New valve designs, and improvements of old designs, now make a complete line of up-to-date safety and relief valves available from this company. An easy-to-use pictorial index shows line drawings of all the basic Farris valve types.

Valves

Everlasting Valve Company has issued a 16-page bulletin (E-150) which describes in detail the features of its standard types of Everlasting Valves. These features include—simplicity of design, straight-through flow, quick action, leak-tight seal and self-grinding sealing surfaces. Illustrations include screwed and flanged types, straight lever and rack-and-pinion operation, and takedown illustrations showing the small number of parts that constitute these valves.

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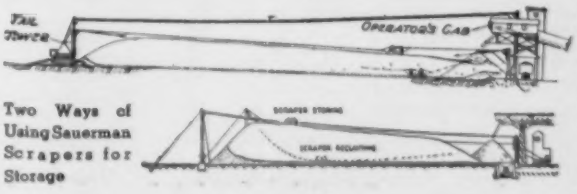

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